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Research Article

PRODUCTION TECHNOLOGY OF HYBRID TRUE POTATO SEED

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ABSTRACT
True potato seed (T.P.S.) technology is based on the natural ability of the potato to produce flowers, which are then fertilizer and set berries that contain potato seeds, which will be used later as planting materials. Initially the main problem of potato hybrids derived from true seed was related to the difficulty of producing uniform potatoes in terms of shape, color, size and quality. Currently there are companies that produce true potato seed, rigorously tested qualitatively superior (free for diseases and pests). Potato tubers are bulky, heavy and perishable, so transportation costs to import potatoes and then deliver to the framer are considerable. To solve this problem, researchers have tried to exploit the ability of potato plants to produce seeds. The distinguish these from "seed potatoes" the seeds are called "TRUE POTATO SEEDS" (T.P.S.).Production of TPS , including selection of parents, flowering, pollination, berry set, and also including direct field sowing of TPS, transplanting seeding from nursery debs to fields.

Key Words: *True Potato Seeds, Horticulture, Potato, Pollination, Hybrids*

INTRODUCTION
Potato is the most important among the tuber crops. It is liked by both poor and rich consumed in different forms. Traditionally Potato is produced by planting tubers. The major limitation is due to non-availability of good tuber seed for planting materials. TPS is a new technology for potato production with many advantages over traditional method of potato production. TPS planting materials can be used for ware potato production as well as seed tuber production depending upon the agro ecological situation and availability of irrigation facilities.

Constraints of Potato Production
Potato is a widely accepted as a commercial crop world- wide. It can give a high economical return. The problems associated with cultivation through seed tubers, TPS technology offers an alternative way to grow a commercial crop was realised. CPRI's Jallandar and Kufri centers started work in a systematic and regular research on TPS. This concentrated on selection suitable parent's lines and assessing the performance of seedlings or seedling tubers of various cross combinations. The potato is a starchy, tuberous crop from *Solanum tuberosum* of the Solanaceae family (also known as the nightshades). The word may refer to the plant itself as well as the edible tuber. In the region of the Andes, there are some other closely related cultivated potato species. Potatoes were introduced outside the Andes region four centuries ago, and have become an integral part of much of the world's cuisine. It is the world's fourth-largest food crop, following rice, wheat and maize. Long-term storage of potatoes requires specialised care in cold warehouses.

The United Nations FAO reports that the world production of potatoes in 2010 was about 324 million tonnes. Just over two thirds of the global production is eaten directly by human beings with the rest being fed to animals or used to produce starch. This means that the annual diet of an average global citizen in the first decade of the 21st century included about 33 kg (or 73 lb) of potato. However, the local importance of potato is extremely variable and rapidly changing. It remains an essential crop in Europe (especially eastern and central Europe), where per capita production is still the highest in the world, but the most rapid expansion over the past few decades has occurred in southern and eastern Asia. China is now the world's largest potato-producing country, and nearly a third of the world's potatoes are harvested in China and India. The geographic shift of potato production has been away from wealthier countries toward lower-income areas of the world, although the degree of this trend is ambiguous.

Research Article

In 2008, several international organizations highlighted the potato's role in world food production, in the face of developing economic problems. They cited its potential derived from its status as a cheap and plentiful crop that grows in a wide variety of climates and locales. Due to perishability, only about 5% of the world's potato crop is traded internationally; its minimal presence in world financial markets contributed to its stable pricing during the 2007–2008 world food price crisis. Thus, the United Nations officially declared 2008 as the *International Year of the Potato*, to raise its profile in developing nations, calling the crop a "hidden treasure". This followed the International Rice Year in 2004.

Potato (*Solanumtuberosum*) seed-tubers are a model system for studying the process of aging in plants. The tubers can be stored (at 4°C and 95% RH) for to 3 years without a loss of viability. However, storage (aging) beyond about 8 months affects a progressive decline in apical dominance, rooting ability, and sprout vigor (Kumar and Knowles, 1993a). In addition to changes in growth potential, aging is accompanied by increased respiration of tubers (Kumar and Knowles, 1996a), oxidative stress (Kumar and Knowles, 1996b), lipid peroxidation (Kumar and Knowles, 1993b), and decreased protein content (Kumar and Knowles, 1993c). Although protein loss is partly due to reduced synthesis (Kumar and Knowles, 1993c), the contribution of proteolysis and the mechanisms by which proteins become damaged and subsequently targeted for degradation with advancing age are unknown. Processes that may lead to protein degradation during aging include (a) increased accessibility of proteins to proteinases resulting from decompartmentation, (b) molecular modifications to polypeptides that enhance proteolysis, and (c) increased activity of proteinases (Dalling, 1987).

USR of Hybrid True Potato Seed for Crop Production

Raising Seedling

Seeds are sown at half cm depth in rows at 10 cm apart in raised nursery beds of 6 inches or 15cm height prepared to good tilth with finely powdered dry cowdung. Provide shade but remove at fifteenth day after sowing. Irrigate with fine rose cane and maintain uniform moisture level. Apply foliar spray 0.1% Urea solution from 15^{th} day after sowing on alternate days till the seedlings are ready for transplanting (24^{th} to 28^{th} day) with 3 to 4 leaf stage. Care should be taken against pest and diseases, particularly against termites and damping off.

Cultivation in the Main Field

Prepare the main field to a good tilth after labeling. Apply Farm Yard Manure 20 to 25 ton and 75:100:150 kg. N:P:K per hectare.

Make ridges (6 inches or 15 cm height) and furrows at 50 to 60 cm. apart in East-West direction. Irrigate the furrows to 3 inches or 7.5 cm height. Transplant the seedling on the next day in the northern side of the ridges at half the height, 15 cm. apart so that the joint of the first cotyledon leaves go underneath the soil. Irrigate the field for quick establishment. On 30^{th} day after transplanting undertake weeding and apply nitrogen at the rate 75kg per hectare. Earthing-up is to be done in such a way that the plants come to the centre of the ridges. Provide irrigation as and when required. Undertake plant protection measures on need base particularly against termites before transplanting and for blights in the standing crop. Harvest the crop when matured.

What is Seedling Tuber

Seedling tubers are small tubers up to 20 gm size used as seed tubers raised from hybrid TPS. Requirement of seed tubers could be brought down to one-third by using seedling tubers, which are popularly known as tuberlets.

Package & Practices for Production of Seedling Tubers Using T.P.S

Prepare beds of six inches height and one & half meter width of convenient length at 75 cm apart. Bring to good tilth mixing with finely powdered well rotten cowdung. Apply Urea, Single Super Phosphate &Murate of Potash @ 20gm, 60gm & 25gm per square meter respectively. Two to three seeds are sown 4 cm apart in a line and row to row distance is 10 cm. In between two double rows distance is 30 cm.

Top dressing with 5 gm. Urea per Square meter at 30^{th}, 40^{th} and 60^{th} day followed by earthing up so that two lines can be covered by a single furrow and the distance between two double rows becomes a furrow to be utilized for irrigation.

Withhold irrigation at around 75^{th} to 80^{th} day after sowing. Cut the haulms at ground level after a week of withholding irrigation. Allow the crop for skin hardening for about seven days. Harvest with care without making injury to the tubers. Discard any tubers which are cut or infected ones. Spread on a dry floor for further curing under diffused light condition. Rogue out any rotten tubers and spray with 3% Boric acid solution for disinfection. Dry the produce with the help of electric fan. Pack in new gunny bags and store preferably in cold store for the next year planting.

Availability of TPS

TPS can be obtained on allotment by the authority by depositing the value of the seed at Rs 20/- per gram through Demand Draft in advance drawn in favour of the Senior Horticulturist, Horti. Research Complex, Nagicherra, Tripura (West), 799 004, payable at SBI, TLA House branch, Agartala. Sale rate of TPS is Rs 20,000/- per kilogram within India. Rate for abroad is 650 U.S. Dollar per kilogram excluding Central Excise Duty (CED), Freight charge etc.

MATERIALS AND METHODS

Tissue Culture

The plant tissue culture medium should contain the ingredients like major inorganic salts, micro inorganic salts, irons, vitamins, carbon source, amino acids, hexitols, plant growth regulators and gelling agents. The concentrated stock solutions of major inorganic salts, micro inorganic salts, vitamins, iron EDTA are prepared separately by dissolving the compounds in double distilled water as per specified quantity required for MS media. Then the final MS media is prepared by adding stock solution at the rate 1ml to 100ml in double distilled water to make the final volume of 1lt. Total requirement of media is calculated on the basis of production target.

Macro inorganic salts: need for macro inorganic salt is higher in tissue culture media. Nitrogen, phosphorus, potassium, sulphur, magnesium, calcium are macro inorganic elements.

Micro inorganic salts: Boron, Manganese, Zinc, Molybdenum, Copper, Cobalt, Iodine are micro inorganic elements, which are required in very small quantity in the media.

Organic Nutrients

a. Vitamins Normally plants synthesize the required vitamins for their growth and development. Vitamins most frequently used in cell & culture media are thiamine (B1), Nicotinic Acid (B3), Pyridoxin (B6), Calcium Pentothanate (B5) etc. Vitamins are normally used in concentration ranging from 0.1 to 10 mg lt.

b. Amino Acids Glycine is the most commonly used one, which plays an important role in the metabolic process of plant.

c. Hexitols Myo inositol is a sugar-alcohol, which is used in the media at the rate 100mg per lt.

d. Gelling agents Agar is most commonly used gelling agents for preparation of semi solid or solid plant tissue culture media. Agar is added in the media at the rate 0.7 to 0.8%.

Steps Followed for Production of Tissue Cultured Potato Parental Lines

1. Selection of healthy, disease free tubers of known parental lines.
2. Treatment of the selected tubers with fungicides like carbendazim etc.
3. Selection of explants: Primary buds are used as explants, which are collected from the selected and pre-treated sprouted potato tubers (healthy & disease free tubers of known parental lines).
4. Explants are surface sterilised with sodium hypo-chloride solution or with mercuric chloride solution for specific period.
5. After surface sterilisation explants are washed thoroughly 4 to 5 times with sterile distilled water to free the explants from any surface sterillent chemicals.

6. Transfer of the explants into the culture media Inoculation of the surface sterilised explants has been carried out into the 25 X 150 mm size test tubes having suitable nutrient media under aseptic condition in laminar air flow inside the inoculation room. The inoculation room environment should always be free of any contaminants (germ free).
7. Incubation Inoculated explants are then kept in the incubation room on the illumination racks, where artificial controlled atmospheric condition are maintained like 16 hours photoperiod and 8 hour dark periods, room temperature being 25^0C (+. 2^0C), RH at 60-70%.
8. Multiplication of plantlets through sub culturingWithin one week after inoculation explants shoe visible growth. The growth of the culture can be observed first a leafy structure along with few roots, after which shoot growth is noticed. After every four weeks the plantlets are sub cultured by taking nodal segments from each plantlet which inoculated in fresh media. Sub culturing may continue as per requirement of plantlets.
9. Transfer of tissue cultured plantlets to soil media from test tubes in net houses.In the month of November four week's old TC plantlets are planted in well prepared sterilised soil of the net house under shed net condition.

Net House for Production of Pre- basic Seed Tubers of Parental Lines

Net house for production of pre- basic seed tuber: Transfer of the regenerated plants to net house is followed only when freely grown plants are obtained. The test tube rooted plantlets are first subjected to acclimatization during which they were kept in outside the incubation room for at least 12 hrs. Before transferring plantlets from the test tube, the roots were washed thoroughly with tap water to remove any trace of the medium. Then plantlets with sufficed leaves were transferred to green house for better growth.

Plantlets are washed free of sugar and planted in the net house (a house like structure size of which is 4mt X 25mt., covered with 35 mesh nylon nets to prevent aphids infestation which act as vector to different potato viruses). Spacing followed is 10cm X 35cm in raised beds. Initially the plantlets are provided with 50% shed net for establishment. Once established the shed net is removed and hereafter no one is allowed to enter or touch the plantlets. An absolute hygiene & sanitation is maintained. Even watering is done through drip lines. Plant prophylactic measures and nutrient management etc. are taken up as per schedule. These plantlets become full grown plants within a short period and give rise to tubers. These tubers are called pre-basic seed tuber. These are harvested after skin hardening and stored in the cold store with many precautions for the next year planting materials for basic seed production.

Basic Seed Tuber Production in Open

The pre basic seed tubers are taken out from the cold store in the next season before the planting time and are put into condition for sprouting. Based upon the experiments conducted earlier and following the aphid population monitoring system the pre basic seed tubers are planted in the open field for bulking in such a way that the tuber production takes place avoiding / escaping the aphid population reaching critical level. The technique followed here is the "Seed Plot Technique", through which good quality seed tubers could be produced in the plains. Proper management with regards to plant prophylactic & nutrition etc. are taken up to maintain the health standard. The main theme is to produce good quality seed tubers at any cost so that no degeneration of tubers takes place due to aphid infestation and virus load. The tuber, thus obtained are graded and kept in cold store after necessary actions as required.

Crossing Block for Producing of Hybrid T.P.S

The Crossing block area is divided into two separate blocks for planting male and female parental lines. The area marked for planting male parents is nearly ¼ of the area reserved for planting female parents. During layout, the quantity of hybrid TPS to be produced is fixed for individual cross combination to avoid a shortage of pollen. There are 2 male and 3 female parents are now utilised for production of different hybrid populations. Male parents are TPS 67 & TPS 13 and female parents are MF I, MF II & TPS 7. Male parents are planted one week before female parents, preferably in the fourth week of October whereas the female parents are planted during the first week of November. Well sprouted treated tubers

are planted in raised beds of 1m width on which in furrows at a 10 cm depth, 10cm apart (from tuber to tuber), with a liner to line distance of 35 cm.

Irrigation

A drip irrigation system is being used in the TPS programme. The flow of drip irrigation and the time schedule are maintained as per optimum requirement of soil moisture and crop growth. Two laterals are drawn in between three rows on a bed and apertures are at 60cm apart.

Light Arrangement for Artificial Illumination

Sodium vapour lamps are arranged over the crossing block area in such a way that the extra illumination can be provided so as to have more than 14 hours light period in a day cycle with a minimum light intensity 45 - 50 lux, which is essential to bring all the plants to come to flowering. HRC, Nagicharra have shown that light intensity of 45 – 50 lux produces the maximum flower buds per unit area.

Staking

Since, in long day situation the plants become taller, therefore, to provide necessary support to plant, half – split 1m long bamboo sticks are fixed 1.5 m apart and tied with 3 –tier longitudinal bamboo splits at 25, 50, and 75 cm height along the side of plant lines. This keeps the plants erect and in line, also and to facilitates pollination work. It also prevents the flowers and berries from touching the soil.

Trimming

After emergence, the plants in the female block are trimmed to retain only 30 stems per Sq.mt. In addition side branches of individual plants are trimmed regularly. Trimming of flower bunches is done to retain 8 - 10 large sized buds per bunch.

Pollen Collection and Pollination

Flowers from the male parents are harvested in the morning and spread over blotting paper in shed house for drying. Other lobes are separated from the flowers and again spread over blotting paper. The dried anther lobes are sieved through specialised sieves to collect the pollen grains in clean glass petri dishes. Immediately after extraction the pollen grains are dried sufficiently at room temperature and stored in small air – tight plastic vials placed in desiccators in refrigerated condition. On the day of pollination the desiccators are brought to room temperature and taken out for pollination.

Female parents ‘TPS 7’ &’ MF II’ are pollinated with male parents TPS 67 and MF 1 with TPS 13. At the time of pollination the vials containing the pollen grains are taken to the concerned flowers of the parents and the stigma of the flowers are dipped into the vials, so that the pollen grains get adhered to the stigmatic surface. This is continued for at least three days to each flower. Small berries are formed and are visually noticed within seven days of pollination.

The optimum time for pollination is from 8am to 10am. Pollination technique adopted is simple and the emasculation process is avoided. The berries can be observed within a week of pollination.

Harvesting, Seed Extraction and Store

After about 45- 50 days of pollination, the berries turn dull green. The well matured berries are harvested, collected in plastic trays and stored in shed for softening. The berries are allowed to ripen at room temperature for about 10 -12 days. Soft, ripe berries are crushed with the help of a berry pulper. A manualreverse screw type fruit juice extracter can serve the purpose of a berry pulper. The pulper with seeds and the juice with same seeds come out from the berry pulper, and collected separately in plastic troughs.

The pulper with seeds is kept at room temperature for 24 hours. The juice with seeds collected separately is also washed the same day. The seeds were treated with 10% HCL for 20 minutes with continuous stirring, with the help of wooden rod and washed with fresh water repeatedly. The seeds are then soaked in 0.5% sodium hypochloride solution for 10 min. To remove any surface seeds contaminants and later washed several times with clean water to make sure the no sodium hypochloride residue remains on the seed. Excess water from the seeds lot is squeezed out by wrapping and pressing in a nylon net.

The seeds are spread in a thin layer on muslin cloth stretched over wooden frame and for drying properly. After drying seeds are stored along with a sufficient quantity of silica gel and moisture content of seed is essentially monitored.

Using True Potato Seeds

- 100 gm. is sufficient to cover one hectare area inserted of planting 2-2.5 tons of potato seed tuber.
- Being hybrid capable of giving more production.
- Absolutely diseases free seed material.
- No cold storage facility is required for storing T.P.S.
- Practically no cost is involved for transporting TPS unlike seed tubers.
- Comparatively more resistance to pests and diseases.
- Net profit is more as cost of cultivation is less and also as the per hectare production is more.
- The seed tubers being utilised could be otherwise used for consumption.
- Cost of production of potato using TPS is approximately 55 % lees in comparison to cost of production of potato using seed tuber.

RESULTS AND DISCUSSION

In the crossing block the produced berries contain hybrid true potato seeds. A single berry produce approx. 300 seeds and one female potato plant produced 6 to 7 berries.

Cross combination of MF I X TPS 13 can produces 100 kg of seeds per hector,Cross combination of MF II X TPS 67 can produces 100 kg of seeds per hector.and Cross combination of TPS 7 X TPS 67 can produces 100 kg of seeds per hector.

In Horti Research Complex, Nagicherra, 200 kg of hybrid true potato seeds from two hector is produced during year 2012-13.Rate of true potato seed is Rs. 16,000/- per kilogram within India, where the rate of true potato seed in abroad is 650 U.S. Dollar per kilogram.

Figure 1: Potato flowers

Figure 2: Crossing block Area

Figure 3: Sodium vapour lamps are arranged over the crossing block area

Figure 4: Berries

Figure 5: Collected Matured berries

On the basis of this study, it is concluded that TPS parent TPS-67 (male parent) has a better combining ability with TPS parents MFII and TPS-7, hence TPS hybrids MFII x TPS-67 and TPS-7 x TPS-67 are better. TPS-13(male parent) has better combining ability with TPS parent MF I (female parent). They produce greater tuber yield than the standard variety Diamont.

It is recommended that more TPS parental lines may be included in the further research programme and suitable parents may be selected that is acceptable to consumers end; To get high and uniform germination of TPS with high yielding ability, efforts may be made to identify progenies that give inherently bold seed and better seed vigor.

100 gm of true potato seed is sufficient to cover one hectare area. Instead of planting 2- 2.5 tons of potato seed tubers, which being hybrid are capable of giving more production. Cost of production of potato using T.P.S. is approximately 55% less in comparison to cost of production of potato using seed tuber. At the same time production may be obtained up to the level of 30 tonnes per hectare.

Conclusion

Extending photoperiod by 4 -5 hours a day using sodium vapour lamps to induce flowering during short days in the plains is required for flowering in order to undertaking hybrid TPS production. For positive manifestation of heterosis in TPS progenies, crosses between ssp. *tubersum* as a female parents (MF I, MF II, and TPS 7) and ssp. *andigena* as male parents (TPS 65 & TPS 13) nay be used. Pollination of each flower at least thrice and no emasculation is suggested for obtaining higher berry and seed set. Fermentation of crushed berries with pulp for 24 -28 hours followed by treatment of seeds with 10% HCL for 20 minutes and 0.5% NaOCL for 10 minutes is suggested. Seeds should be dried to a moisture level to below 6% and stored in sealed plastic containers with silica gel as a desiccant at room for subsequent use. Prior to distribution to the farmers these produced TPS need to be analysed for its' ability to germination & vigour.

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