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POTATO CULTIVATION IN INDIA : ITS PAST, PRESENT AND FUTURE*

K.P. SHARMA



It is exhilarating for me to extend a hearty and cordial welcome to you all to the 8th Annual General Body Meeting of the Indian Potato Association. I consider it a special privilege to have the opportunity of sharing my experiences, views and projections with you so that an appropriate work plan, fitting in the present day need-frame and accommodating futuristic strategies, could be evolved for improving the potato crop and its gainful utilization. We are meeting today in an atmosphere of confidence, hope and optimism about the future of potato in this country, though there are many short-comings and gaps looming large looking in our face for remedial measures. The steady forward steps taken in the past and the scientific progress attained are safe foot-holds promising better days for the crop. We can hope to welcome the 21st century with potato playing a purposeful role in the agricultural economy of the country. With such expectation and stimulating probabilities, I wish to narrate the genesis of the progress and the perspective of the problems of so far and future. Only such analytical approach would provide proper understanding and create right temper to meet challenges.

The potato came to India in the middle of 17th century and appeared on the agricultural scene in the early years of 19th century. It has, however, found great favour with the farmers as a cash crop because of its virtues of high economic potential and wide consumer acceptability due to its nutritive and market qualities. Its well known amenability to grow under all kinds of ecological situations, right from sea-shore to snow-line, has been a big survival factor for this crop. Today, it occupies a prominent place in our cropping schemes followed in different agro-climatic situation.

Convinced of the desirability of initiating an independent research programme for the country instead of importing varieties from western countries and employing transplanted technology, which were not the best for our specific conditions, a Scheme on Potato Breeding was started in 1935 under the aegis of the ICAR.

The results of practical value emerged from the venture. The necessity to organize effective research programme for an all sided improvement of the crop, the Central Potato Research Institute was established in 1949. Significant advancements in acreage, production and productivity of potato have been attained since then. It is seen that though acreage under potato, especially during last 10 years or so, has remained more-or-less static, the production has registered a significant increase and at present stands at nearly 13.5 million tonnes with an average of approximately 155 qtl/ha. Though potato occupies only 0.4% arable land in the country, it figures 4th in terms of acreage in the world and stands fifth for the total production.

*Presidential address delivered on the occasion of the 8th Annual Meeting of the Indian Potato Association held at BCKVV, Kalyani on the 10th August, 1987.

In India potatoes are grown in widely diverse ecological situations, ranging from temperate areas in the hills to subtropical north Indian plains and the day neutral, warmer plateau region. South Indian coastal areas and the Nilgiri hills offer suitable climatic conditions where three consecutive crops are feasible. In view of such geophysical variability and climatic differences, the country has been divided into six potato cultivation regions :

- i) The North Indian Himalyan Hills.
- ii) The North Western Plains (Punjab, Haryana and northern parts of Rajasthan).
- iii) The Western and Central Indo-Gangetic Plains (Western U.P; Madhya Pradesh and Rajasthan).
- iv) The Eastern Gangetic Plains (eastern UP; Bihar, West Bengal and coastal plains of Orissa).
- v) The Plateau region: a) Mid country plateau; b) Southern peninsular plateau.
- vi) The South Indian hills of Nilgiris.

As is well discerned from the regional demarcations, the major variable factors in different regions are the temperature and its range, humidity, rainfall and its distribution and the soil structure and texture. The day-length is yet another important independent influential factor. It is seen that under long day conditions, the plants generally put up luxuriant growth, extended to a longer period but give less tuber production in comparison with short-day crops.

Nearly 80% potato production of the country comes from the Indo-gangetic plains. The hills account for about 8–10% production and the plateau region contributing the remaining part. With the standardization of quality seed production technology for the plains (Seed Plot Technique) the health standard of the seed has improved. Introduction of new improved varieties suitable for different areas and having better tolerance to degenerative causes is also an important contributory factor in enhancing production. On the other hand, now the late blight disease appears almost regularly in epidemics not only in the hills but with similar severity in the plains as well. Newer diseases and pests like bacterial wilt, common scab and tuber moth are becoming important problems. I have observed that the top shoot borer is becoming a major potato pest in Gujarat, Maharashtra, Chhota Nagpur hill areas in M.P., Bihar and Orissa, particularly in Kharif crop.

The per-capita consumption of potato in the country has increased only marginally from 8 kg in 1950 to 14 kg in 1980 whereas in the three decades, the production has gone up more than three times. Alternative methods of utilization of the produce have still not been developed. Therefore, even slight increase in production brings down price appreciably, sometimes forcing distress sales. Another equally important reason for such situation is inadequacy of proper storage infrastructure. The poor economic status of the farmers compels them to sell their produce immediately after harvest thus, precipitating a (false) glut situation specially in production centres. The lack of proper and fast mobility to consuming areas adds

to this problem, making both the producer and the consumer lose. In a way, the whole enterprise of potato production adjusts itself on the inter-balance between these variables.

Though in the preceding paragraphs some of the natural and managerial factors casting influence on production have been brought into focus, they do not remain the handicaps of earlier magnitude with the new technology now available.

As is well known, potato suffers from a number of problems related to diseases, insect pests, physiological and ecological conditions. It needs right kind of variety, possessing resistance to major diseases and pests which should be capable of producing high yields of quality tubers meeting consumer preferences. Since establishment of the Central Potato Research Institute in 1949, later on supported by the All India Coordinated Crop Improvement Project in 1971 involving participation of Agricultural Universities and the State Departments of Agriculture/Horticulture, multidisciplinary research is being carried out to obviate the field oriented problems. It would be quite in line to highlight some of the major achievements made through these efforts.

Varietal improvement: With the inauguration of potato research programme, collection of indigenous and exotic germplasm was launched. The indigenous variability on analysis was identified belonging to 16 distinct cultivars. Out of them eight cultures were early introductions from western countries and the other eight belonged to an unknown source primarily representing *Andigena* group in their characteristics. A sizeable varietal and species collection was built up with accessions obtained from foreign sources. This collection has been utilized as the repository of genetic variability and extensively used in breeding programmes.

To start with, the popular varieties upto the mid forties were Phulwa, Darjeeling Red Round (DRR), Gola, Up-to-Date, Satha, Great Scot, President, Magnum Bonum, Arran Chief, Arran Consul, Craigs Defiance and Majestic. There were a few other cultivated sorts as well, but they occupied negligible area under the crop. In 1957, two varieties Kufri Safed and Kufri Red, developed as clonal selections from Phulwa and DRR respectively were released. Another clonal selection developed from Up-to-Date was also introduced in cultivation around this time. Meanwhile, some promising hybrids were derived from the breeding projects which resulted in release of varieties like Kufri Kisan, Kufri Kuber, K. Kumar and K. Kundan.

Within few years of introduction of these varieties, another group of improved varieties was released from 1967 to 1970. This group included Kufri Chandramukhi, Kufri Sindhuri, K. Chamatkar, K. Jyoti, K. Jeevan, K. Naveen, K. Khasi-Garo, K. Alankar, K. Neelamani, K. Muthu, K. Dewa, K. Sheetman and K. Lauvkar. These cultivars got into their own areas of suitability. In the previous five years up to 1982 four additional varieties Kufri Badshah, K Bahar, K. Lalima and K. Sherpa have been released. All of them, combine a level of resistance to late blight disease with high yield potential. A new variety Kufri Swarna, having resistance to cyst nematodes and late blight has been recommended for Nilgiri hills where these problems exist.

Incompatibility and non-crossability in species and varieties have been big constraints in potato breeding. To overcome these restrictions, studies were carried

out on the crossing behaviour of the species belonging to different 'series' and 'Ploidy' levels. It has been observed that genetic incompatibility in species follows the 'oppositional factor hypothesis' and behaves in 'multi-allelomorphic series' fashion. Due to these reasons, most of the diploid species do not cross with commercial tetraploid varieties. Cytoplasmic incompatibility has also been seen in case of *Solanum demissum* and *S. tuberosum* crosses, where crosses are successful only unilaterally using *S. demissum* as maternal parent. For building up, exclusive field resistance to late blight disease a new species *S. verrucosum* is being harnessed. A number of other species like *S. vernii*, *S. stoloniferum*, *S. chacoense* and *S. acaule* are also being utilized under different breeding programmes. This not only ensures incorporation of desired resistance characters etc, but also introduces genetic variability beyond the limits of *Tuberosum* alone.

Technique for efficient crossing in field and indoors have been standardized. Updated methods for preservation of the germplasm *in vivo* and *in vitro* which include field cropping, glass-house multiplication, true seeds and tissue culture maintenance, low temperature storage and pollen repository are being employed.

Crop management: Information has been accumulated on aspects of soil fertility levels and its conditions, optimum time of planting and harvesting, nutritional requirements, water management, weed control and cultural practices for different regions. This information is being released for benefit of the farmers through extension agencies and the programmes of development projects like Lab to Land, Operational Research Project and Tribal Area Development scheme being run by the Institute.

Nutrition: The experimental evidence indicates that efficiency of utilization of nitrogenous fertilizers in potato is about 40%. Application of calcium ammonium nitrate (CAN) or ammonium sulphate (AS) is more or less equally beneficial to the crop and meets the optimum requirements. However, the efficiency of urea is estimated to be nearly 20% less than the former chemicals. It was further noticed that urea as the nitrogen source affected the germination percentage adversely if applied in one dose which released more than 50kg/ha nitrogen. However mixing urea with Neem cake and pyrites proved a corrective combination in this respect.

The optimum doses of the three major nutrients (N, P & K) in different soils have been worked out. The best combinations have been found to be 150, 30, 100 kg/ha (NPK) in the alluvial soils 120, 50, 80 kg/ha in hill areas, 100, 40, 80 kg/ha in red soils of plateau region and 100, 20, 50 kg/ha in the black cotton belt. In general, application of 30 tonnes/ha of farm yard manure has proved sufficient to meet phosphate and potash needs of potato and subsequent rotational crops. FYM is less efficient source of nitrogen in hill soils but it enhances N fertilizer use efficiency by improving soil condition. Soils containing less than 20% organic carbon tend to exhibit P & K deficiencies. Foliage nutrition application with urea has proved better than soil application (as second dose), specially in the hills.

The efficiency of P fertilizers is about 10–15%. Soak treatment of tubers in solution of 1.5% single superphosphate economises on P dose for soil application by nearly 22 kg/ha

K uptake efficiency in potato has been found to be 40–50%. K_2SO_4 (potassium sulphate) is seen to be a better source of K than potassium chloride. Interactions between N & K have been found highly significant in positive direction.

Information on the role of some important micronutrients like Zn, Ca, Fe, Mn and boron has been obtained and correcting practices worked out.

Time and methods of fertilizer application have been studied and appropriate recommendations made for various regions.

The experiments on soil and water management in hills have revealed that the gradients of 20°, 5° and 0.5° resulted in wash out of upper soil to the extent of 50, 30 and 20 tonnes/ha respectively. Bench terracing, furrow mulching and contour planting appreciably reduce soil erosion in potato fields. Pine needle mulch or polythene film spread in furrows ensure efficient water harvesting and moisture conservation. In the plains, moisture stress before tuber initiation reduced the tuber number per plant and during the bulking phase affected the size of the tubers. Practices for weed control by chemical methods have been standardized. Pre-emergence application of Lasso (2.5 l/ha), Linuron (0.5 kg/ha) or Toke E-25 (4.0 l/ha) and post-emergence treatment with Stam F-34 @ 2.5 l/ha and Gramaxone @ 2.5 l/ha are recommended.

To reduce the cost of cultivation and for timely completion of operations, some mechanical devices have been fabricated. Fertilizer drill-cum line marker and planter, soil crust breaker, potato grader, potato digger, granular insecticide applicator, packing-bag holding device and solar dehydrator (for drying chips & cubes etc.) are in increasing use.

Under the physiology and biochemistry fields, the experiments have shown that depending on the temperature and day length conditions the harvest index varies 67–91% in autumn (short days) and 56–78% in spring (long days) crops.

Intrinsic viscosity of potato starch (responsible for tuber texture) is higher when sulphate of potash is used as fertilizer than by applying muriate of potash. Certain other findings relating to amino-acid, glycoalkaloids, enzymes etc. have been made (which may not be of relevance to refer in this address) are of significant value as guiding pointers for paving a smoother path-way to synthesize a more efficient plant for cultivation.

For storage of potato, a passive evaporative cooling store is being developed in which the produce could be kept in good condition for nearly 4–5 months without deterioration. Treatment of tubers with the sprout suppressant chloroprotham eliminates sprouting under these conditions.

Viruses: Viruses have proved to be stubborn problem. There is no assured workable method for adoption at commercial scale to free the plant of virus infection once it has occurred. To a limited extent, meristem tissue culture or other laboratory techniques are being used to isolate virus free plants from the infected stocks.

Since more serious viruses (PVY, PVA, PLRV) are all aphid transmitted, studies have been conducted on the appearance, population build up and life cycle of the

important aphid vectors, so that strategies for controlling or bypassing them could be evolved. For testing the stocks, serological, chemical, histo-pathological and thermal treatment techniques are being utilized. Univalent and bivalent anti-sera are being procured for use in field tests against viruses. ELISA and LATEX techniques of testing are also being used.

To keep down the aphid population, chemical treatments have been recommended. Application of Thimet @10kg/ha. at planting time, wards off aphid appearance for nearly 45 days. Sprays with Metasystox @ 1.0 l/ha. at weekly intervals from 10 days before appearance of aphids keep the crop healthy.

Fungal diseases: Late blight is the most dreaded disease in this group. Its sudden appearance and speedy devastating capacity do not leave chance for implementation of effective control programmes. Protection with chemicals can be achieved effectively only if varieties possess a reasonable degree of resistance. Emergence of new physiologic races at regular short intervals, with change in varietal pattern, make the 'vertical resistance' redundant. The 'horizontal resistance' promises a lasting protection. As stated before breeding programmes in this direction is under way at the CPRI. Chemical control measures have also been found out. Best protection is provided by Dithane M-45 (0.2%) and Bordeaux Mixture (1%) sprayed at 10-15 days intervals from middle of December in the plains and middle of June in the hills. A fore-casting system for late blight has been standardized to help farmers in taking timely action for sprays before actual appearance of the disease.

In case of tuber-borne diseases (which survive in soils as well), soil treatment with Brassicol (30 kg/ha) and tuber treatment with Agallol-3 (0.5%) or Emison - 6 (0.25%) for 20-30 minutes before storage have been recommended. The tuber treatment also proves effective against common scab and checks occurrence of Fusarium, Phoma and powdery scab, as well. Treatment of tubers with acetic acid (0.1%) + ZnSO₄ (0.05%) for 30 minutes also gives equally effective protection against black surf.

In Darjeeling area of West Bengal and in Sikkim, wart disease has gained predominance. Fortunately, the resistance to this disease is present in commercial varieties and can be easily incorporated in new bred out cultures.

Bacterial diseases: The commonly known bacterial diseases other than bacterial wilt and brown rot are bacterial soft rot and bacterial leaf spot. They have been noticed to occur sporadically and are not recognised of much consequence. Bacterial wilt and brown rot (*Pseudomonas solanacearum*) has now attained wide prevalence, being more aggressive in hills of medium altitude (upto 2000 m. above sea level). The bacterium survives in soil for a considerable period. It is observed that the bacterium does not survive for more than 50 days in monthly maximum temperatures of 40°C or above (when the soil moisture is also low). However, it remains viable in hill soils under moderate temperatures and fair soil humidity even when host crops are not cultivated for a number of years. Acidic soil proves more suitable for the bacterium.

So far no source of resistance is located for the biotypes existing in the country. To reduce the incidence of infection, cultural practices viz; straw burning in fields in

the hills and 'hot weather' cultivation in the plains and plateau regions are advocated. Crop relations with cereals and millets for two or three years also help in bringing down intensity of the disease.

Entomology and Nematology Investigation: The surveillance of potato pests revealed that apart from aphids (which are omnipresent in most parts of potato growing areas), cut worm, tuber moth and epilachna are the other important pests. Cyst nematodes are a major problem in the Nilgiri hills.

Cut worms take a heavy toll of emerging succulent plants, particularly if the soil is dry. The estimates of damage range from 1 to 35%, depending on weather conditions. Dursban @ 2 l/ha proves effective. Though Heptachlor shows high success, the chemical is not advised for use due to its residual toxicity.

Tubermoth is prevalent in the hill areas and plateau region. In Maharashtra and the Nilgiri hills, it causes heavy damage in stores. Successful control measures are now available. Under field conditions application of Monocrotophos @ 0.6 kg (a.i)/ha followed by Phenthorate @ 0.75 kg (a.i)/ha are quite effective. Tuber treatment with synthetic pyrethroides inhibits damage in store for about 4 months. In biological approach to control tubermoth, parasites (*Apanteles subandinus*, *Chelonus blackburni* and *Origilus jenniae*) reduce incidence upto 25%.

Cyst nematodes (*Globodera* spp.) are of major concern in the Nilgiri hills. The damage caused by them is of high proportion in terms of disfiguration and rottage of the produce and reduction in yield. As indicated earlier, a cultivar Kufri Swarna showing resistance to all prevalent biotypes has recently been introduced for cultivation in this region. For controlling through chemicals, application of Aldicarb, applied as 'spot' or furrow placement at planting or germination time decreases cyst populations below the thresh hold level.

Seed Production: Traditionally, the hills enjoy reputation of suitability for seed production. Scientifically, the concept is sound because in the higher altitudes the aphid population proportionately diminishes due to climatic factors. The hills of Himachal Pradesh and Uttar Pradesh had been the main seed suppliers for the country. However, the system exposed its limitations as the cultivation in the plains and plateau regions picked up. The area for seed production in the two states proved inadequate to meet total seed demand of the country. The hill produce harvested in September-October remained dormant at planting time in the plains (October-November) necessitating dormancy breaking treatment. Lack of proper and timely transportation and additional costs involved in the operation went against to economics. The varieties grown in the hills were always not the popular cultivars of the importing areas. All these factors combinedly discouraged dependability on hill seed in the plains and plateau areas.

In view of these constraints and problematic blockades, efforts were made to explore feasibility of raising healthy seed in the plains itself. The data compiled on aphid build-up was critically analysed. It brought to light the facts that aphids generally start appearing after the middle of December in the North western plains and the critical level of population is reached around the end of first or in second

week of January. Taking clue from this scientific knowledge, a new concept of 'Seed Plot Technique' was developed. The technique is now, so well known that it does not require elaboration here. In fact, it has proved to be a 'break through' in Indian Potato Cultivation. The areas of Punjab, Haryana, Uttar Pradesh, Bihar, Madhya Pradesh and Rajasthan are quite suitable for raising seed crops adopting the technique with advantage. In the last about two decades, the methodology has become the harbinger of seed production programme in the country. Some of the states that do not have favourable climatological conditions for seed production have become ready purchasers for the seed producing areas of the northern plains.

Seed Certification: A full-fledged scheme of seed certification, which involves participation of the Central Institute, National Seed Corporation, Agriculture Universities and State agencies is functional in the country. Under the programme CPRI holds responsibility of producing 'breeders seed' of the commercial varieties. The breeders seed is distributed to National Seed Corporation, State Departments and the Agricultural Universities for multiplication and production of 'foundation seed'. This (foundation) seed is distributed to selected progressive growers who raise crops under the technical supervision of the above Govt. organizations in accordance with norms and methods prescribed for the purpose. The farmers' crops are inspected by a panel formed by the seed certification organizations and a certificate declaring fitness (or otherwise) of the produce as seed is issued. The produce goes as 'certified seed' for general cultivation.

New thrusts for future: It might sound paradoxical to plan enhancement of production when the present day level itself goes abegging for gainful utilization; so true in case of potato. A direction is, however, being proposed with optimism to derive maximum economic returns through concerted attention on utilization aspects. Taking the view that there is scope for expanding utilization of the produce, I am tempted to touch on the unexplored, non-conventional technologies to be brought under the folds of research involvement to further augment production levels and launch projects for its full utilization.

1. The understanding of the cyto-genetical behaviour in potato and its implications in varietal evaluation is restricted due to cytological 'separations' and genetical 'barriers'; like incompatibility, sterility and deleterious factors in the conventional methods of breeding. The new techniques of protoplast culturing, possibility of somatic hybridization and single-cell 'cloning' offer a potential field of approach obviating the above mentioned constraints.
2. 'Genetic Engineering' can prove to be of great avail in transferring desirable attributes into the commercial varieties.
3. The advantages of growing potato crop with true seed are well established by now. Proper cross-combinations and/or appropriate selfed lines have to be identified and suitable package of cultural practices developed for successful adoption of the technique of True Potato Seed (TPS) cropping.
4. Research programmes on nutritional quality and storage aspect to enhance the shelf-life of the potato without cold storage need to be strengthened on priority basis.

5. Due cognizance should now be given to problems like brown rot and bacterial wilt, common scab and tuber moth which are becoming of common occurrence. New problems like top shoot borer in the plateau region also deserve early attention before they attain greater magnitude.
6. Production-wise more effective seed production programme should be launched to meet the demand of quality seed in the country.

Utilization of the produce: Potato is a semi-perishable commodity. It needs care and proper conditioning for its long duration preservation till used. Cold storage space presently existing in the country can take care of only 30% of the produce. Nearly 15% produce goes for table consumption within 2–3 months following the harvest without necessity for storage. The remaining 55% needs storage either as seed or for staggered release for table consumption. If the stocks are exposed to high temperatures of summers, heavy rottage and quality deterioration take place. The losses in home storage can run as high as 60–80% in a period of 4–5 months.

In addition to the conversion oriented proposals, there appears good scope for export to the neighbouring countries, South eastern nations and the countries of middle east either as seed, raw potatoes or as finished items. Similarly in agro-climatic conditions of India and countries like Nepal, Bhutan Bangladesh, Srilanka and Pakistan emphasises the possible viability and suitability of our varieties there.

The post harvest technology research needs to be strengthened. By the turn of the century, India envisages production to the tune of 20 million tonnes. It, therefore, becomes imperative that due attention is given from now itself to ensure proper utilization of the produce so that a sustaining balance is maintained between production and utilization.

It is evident from the foregoing description of the potato research and development programmes pursued in India that the crop has grown to a mature stature and holds promise to play a bigger, intimate role in the agricultural economy of the country in years to come.

LEAF ANALYSIS FOR BALANCED NUTRITION OF POTATO*

J.P. SINGH¹

Abstract: Critical concentrations and balanced ratio of nitrogen, phosphorus and potassium in potato leaf were estimated. Content of N, P and K in potato leaf explained 70 percent variation in the tuber yield. Leaf N alone accounted for maximum variation (60% linear and 63% quadratic). Leaf N and K of 5.37 and 3.62 (%DM) respectively were critical. Leaf P of 0.367 (%DM) was not limiting for maximizing the tuber yield. Balanced ratio of N : P : K in potato leaf was 1 : 0.08 : 0.79.

INTRODUCTION

Monitoring balanced nutrition of potato by leaf analysis is becoming essential for efficient use of fertilizers in potato. Because of increasing prices fertilizers account for even greater proportion of total inputs. Imbalanced nutrition may reduce the tuber yield and affect the economics of cultivation. Correcting nutritional imbalances in the growing season as needed may result in more efficient use of fertilizers. Some information on critical limit of potato leaf N is available (2, 6). However, information is lacking on critical limits of P and K and balanced ratio of N : P : K in potato leaf. Critical limits and ratio of N, P and K in potato leaf for maximizing yield of irrigated autumn potatoes of north-western plains of India are reported in this paper.

MATERIALS AND METHODS

Samples of 4th leaf from top of the shoot (30 to 40 in numbers) 45 days after planting were collected from each plot of a fertilizer experiment in the year 1982-83 at Central Potato Research Station farm, Jalandhar. The fertilizer experiment was laid out in a 4³ confounded design (4). All combinations of four levels each of N (0, 100, 200, 300 kg/ha), P (0, 31, 62, 93 kg/ha) and K (0, 84, 168, 252 kg/ha) were tried in 4 blocks of 16 plots each. Potato cv. *Kufri Chandramukhi* was planted in plots 3.0m x 2.2m with a spacing of 50cm x 20cm in the second week of October 1982 and was harvested at full maturity in the third week of January 1983. Soil of the experimental site was sandy loam with pH 7.1, organic carbon 0.417%, 72 ppm N (alkaline permanganate method), 19 ppm P (Olsen-P) and 50 ppm K (1N, pH7, ammonium acetate extractable).

Leaf samples were dried at 60°C and ground to pass through 40 mesh sieve. Samples were analysed for total N (5). Total P in the triacid digest was determined by 1, 2, 4 — aminonaphthol sulfonic acid-reduced molybdophosphoric blue colour method and K by flame photometer (3).

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*Publication No. 920, CPRI, Simla

RESULTS AND DISCUSSION

Regression of nutrients in leaf on tuber yield showed that accumulation of N, P and K in leaf had a definite bearing on tuber yield (Table 1). Total nitrogen alone explained the maximum variation in yield (60% linear and 63% quadratic). Inclusion of quadratic functions of leaf P and K with N explained 70 per cent variation in the tuber yield.

Critical concentrations: Main effects of N application on leaf N and tuber yield was calculated by grouping all treatment combinations with same levels of N together (Table 2). Similarly main effects of P and K application on leaf P and K respectively and tuber yield were calculated. Application of 300 kg N/ha yielded significantly more than 100 kg N/ha (Table 2). However, the levels 200 and 300 kg N/ha were at par. Increases in leaf N were significant upto 300 kg N/ha (Table 2). Therefore, leaf N of 4.87 (%DM) at 100 kg N/ha was taken as deficient while leaf N of 5.87 at 300 kg N/ha as sufficient. The midpoint (5.37%) of these two leaf N values can be classified as critical. The critical level of a nutrient is that concentration in a specific plant part at a specific stage of growth at which a 5 or 10 per cent reduction in yield occurs, or that concentration which is associated with the breaking point of the nutrient response curve or that concentration which is at the midpoint of the

Table 1: Regression of leaf N, P and K (%DM) contents on tuber yield of potato

Regression equations	R ²
1. $Y = -113.1253 + 82.6530 N$	0.5999
2. $Y = -554.5796 + 269.5319 N - 19.0254 N^2$	0.6329
3. $Y = -250.8333 + 105.1528 N - 3.1717 N^2$ + 481.1654 P - 162.6835 P ² - 26.9826 NP	0.6414
4. $Y = -451.1030 + 208.2456 N - 14.5180 N^2$ + 12.5269 K - 2.25 K ² + 3.9410 NK	0.6749
5. $Y = -165.587 + 126.6147 N - 4.9764 N^2$ + 8.6983 P - 139.3463 P ² - 34.4356 NP + 8.2724 K + 0.1378 K ² - 8.8366 NK - 7.28 PK + 24.577 NPK	0.7053

Where Y = tuber yield (q/ha). N, P & K are leaf nitrogen, phosphorus and potassium, respectively.

Table 2: Main effects of levels of nitrogen, phosphorus and potassium on leaf composition and tuber yield of potato

NITROGEN			PHOSPHORUS			POTASSIUM		
Level of N(kg/ha)	Leaf N (%DM)	Yield (q/ha)	Level of P(kg/ha)	Leaf P (%DM)	Yield (q/ha)	Level of K(kg/ha)	Leaf K (%DM)	Yield (q/ha)
0	3.76	153	0	0.367	304	0	2.55	276
100	4.87	333	31	0.401	309	84	3.64	309
200	5.53	354	62	0.402	295	168	4.05	298
300	5.87	374	93	0.439	306	252	4.69	331
C.D. (5%)	0.26	36.9		NS	NS		0.63	52.6

transitional zone between deficiency and sufficiency levels (7). Singh and Brar (6) reported a similar value of 5.35 (%DM) as critical leaf N concentration for potato in alluvial soils of Punjab.

There was no response to P and leaf P was not affected significantly by P application (Table 2). Therefore, a leaf P of 0.367 (%DM) obtained without P application could be classified as sufficient. High level of available-P (19 ppm) in the soil explained the absence of response. Soils having more than 10 ppm of available-P are not likely to respond to P application (1).

Leaf K increased significantly with K application upto 252 kg/ha (Table 2). Application of 252 kg K/ha significantly increased the tuber yield over the control, however other levels of K were not different (Table 2). Therefore, leaf K of 2.55 per cent obtained without K application could be taken as deficient, while leaf K of 4.69 per cent at 252 kg K/ha as sufficient and midpoint (3.62%) as critical.

Balanced ratio of N, P and K in Potato leaf: For calculating balanced ratio of N, P and K in potato leaf the tuber yield and leaf analysis data were classified into two. First group (balanced) included all the treatments where N and K were not limiting. Results discussed above suggested that treatments with N and K even at their first level of application or more could be taken as not limiting with respect to N and K. The second group (unbalanced) included all the treatments which were without N or K or both. Since P was not a limiting factor level of P application was ignored. Balanced application of N and K significantly increased the tuber yield by 60 per cent over the unbalanced group (Table 3). The ratio of N : P : K in leaf was 1 : 0.08 : 0.79 in the balanced and 1 : 0.08 : 0.67 in the unbalanced group (Table 3). Deviations from K/N ratio of 0.79 in potato leaf could be taken as an index of unbalanced nutrition of these two elements.

Results showed that concentration of N, P and K in potato leaf explained 70 per cent variation in the tuber yield. Leaf N and K of more than 5.37 and 3.62 per cent (%DM) respectively maximized the tuber yield and leaf P of 0.367(%DM) was not limiting for the maximum yields. Balanced ratio of leaf N : P : K for potato was 1 : 0.08 : 0.79.

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Table 3: Nutrient concentration ratio in potato leaf and tuber yield as affected by balanced application of nitrogen and potassium

Treatments	Frequency	Yield (q/ha)	Leaf concentration (%DM)			Nutrient ratio N : P : K
			N	P	K	
Balanced	36	366	5.45	0.436	4.32	1 : 0.08 : 0.79
Unbalanced	28	223	4.44	0.359	2.98	1 : 0.08 : 0.67
C.D (5%)		38.8	0.43	0.05	0.52	

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EFFECT OF PHASIC AND RECURRING SPELLS OF WATER STRESS ON GROWTH OF POTATOES AND N-UPTAKE

H.S. SEKHON¹ AND MUKHTAR SINGH²

Abstract: Field experiments were conducted on loamy sand at Ludhiana to study the responses of the potato crop to mild stress and severe stress imposed at (I) tuber initiation stage, (II) early tuber enlargement stage and (III) late tuber enlargement stage, individually and repeatedly. Mild stress was created by irrigating the crop at 25–33 mm net cumulative pan evaporation (CPE) and severe stress, at net 39–49 mm CPE.

Severe water stress at stage I alone reduced seed yields by 3.20 and 3.27 t/ha and the number of seed tubers by 6.6 and 10.0/m² in 1978–79 and 1979–80, respectively; that at stage II depressed 'ware' rather than seed and that at stage III kept down 'ware' only. The effect of stress at the different stages individually on total yield and N-uptake was almost the same. Plant height was most sensitive to the stress at stage II, followed by that stage I. Repeated severe stress accentuated the deleterious effect on plant growth and yields, though the cumulative effect was lower than the sum total of the effects of single-stage stresses individually. The response to mild stress, though subdued, pointed in the same direction as that to severe stress.

In 1979–80, total yield fell from 14.1 to 7.5 t/ha with decrease in mean relative leaf water content (RLWC) from 87.5% under no stress to 75.7% repeated stress. The rate of fall in yield per unit decrease in relative leaf water content was steeper under single-stage stress treatments.

INTRODUCTION

Earlier water regime experiments on potatoes brought out the need for frequent irrigations at low soil moisture tension in the plains of India (5). In recent years, emphasis has shifted to irrigation scheduling based on cumulative pan evaporation (CPE) values, making allowance for rainfall, in view of the practical ease of this approach. Some studies have been carried out to evaluate the effect of water stress in terms of soil moisture tension at defined stages of growth with a view to improve irrigation efficiency consistent with obtaining high yield (1, 2). In the previous studies, plant water stress was rarely determined to relate it to growth and yield. The studies reported here were directed to investigate the effect of phasic stress imposed at three stages of development, singly and repeatedly, not only on plant growth and N-uptake but also on the grades of produce. Attempt was also made to interpret responses in terms of relative leaf water content (RLWC).

MATERIALS AND METHODS

Field experiments comprising of 8 water stress treatments (including no stress) in 1978–79 and 9 such treatments in 1979–80 (Table 1) were conducted on irrigated potato crop in randomized blocks with 4 replications. The studies were made at the

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Punjab Agricultural University, Ludhiana, situated in the sub-tropical region. The soil of the experimental fields was loamy sand. The available moisture storage capacity of the soil layers in the root zone ranged from 12.2 to 13.3 per cent on volume basis. The average bulk density of soil was 1.55 and 1.67 g/cm³ in the experimental fields in the two years, respectively. Seed tubers of variety Kufri Chandramukhi were planted at 60 x 20cm spacing on 29 September, 1978 and 3 October 1979, respectively. Fertilizers at 60 kg N, 60 kg P₂O₅, and 120 kg K₂O/ha were applied before planting following by two top dressings of 60 kg N/ha each about 20 and 30 days after planting.

The entire crop was irrigated uniformly according to the normal practice till plant establishment i.e. up to 18 October in 1978 and 23 October in 1979. Thereafter, from 24 October to 21 December in 1978 and from 28 October to 19 December in 1979, the crop was irrigated according to differential irrigation schedule (Table 1). The crop under no stress (So) received 16 and 14 irrigations at 5–7 days intervals generally during the respective years as and when the cumulative U.S. pan evaporation in excess of rainfall (net CPE) attained 12–15 mm value. Stress was created by missing irrigation (s) at specified stages of crop development, in the stress-involving treatments.

Table 1: Irrigation schedule for different treatments during 1978–79 and 1979–80

Sr. No.	Stress level at stages			Irrigation dates during stages										
	I	II	III	I			II			III				
				18/10 23/10	24/10 28/10	1/11 3/11	3/11 8/11	14/11 13/11	19/11 19/11	26/11 25/11	4/12 3/12	15/12 9/12	25/12 19/12	1978 1979
1	O	O	O	+	+	+	+	+	+	+	+	+	+	
2	M	O	O	+	-	+	+	+	+	+	+	+	+	
3	S	O	O	+	-	-	+	+	+	+	+	+	+	
4	O	M	O	+	+	+	+	-	+	+	+	+	+	
5	O	S	O	+	+	+	+	-	-	+	+	+	+	
6	O	O	M	+	+	+	+	+	+	+	-	+	+	
7	O	O	S	+	+	+	+	+	+	+	-	-	+	
8	M	M	M	+	-	+	+	-	+	+	-	+	+	
9	S	S	S*	+	-	-	+	-	-	+	-	-	+	

*This treatment was added in 1979–80

O means no stress — Irrigation scheduled when CPE approximated 12–15 mm

M means mild stress — Irrigation delayed till the CPE approximated 20–25 mm to create the mild water stress at the stage (s) specified

S means severe stress — Irrigation delayed till the the CPE approximated 35–40 mm to create the severe water stress at the stage (s) specified

+ = Irrigation applied I = tuber initiation stage
 - = Irrigation omitted II = early tuber enlargement stage
 III = late tuber enlargement stage

Single-stage mild (M) stress was imposed by missing one irrigation at one or the other of the 3 stages, viz, I (tuber initiation), II (early tuber enlargement), and III (late tuber enlargement) and the treatments were designated as M I, M II and M III, respectively. Correspondingly, phasic severe (S) stress was imposed by missing two irrigations at the respective stages individually in treatments S I, SII and S III. Recurring triple-stage mild stress (MMM) where the stress was imposed repeatedly at all the three stages was kept as additional treatment in both the years, but recurring severe stress (SSS) was introduced in 1979–80 only. The stress involved prolongation of irrigation interval at increased net CPE at specified stage/s as given in Table 2.

In 1979–80, leaf water stress was measured in terms of RLWC by the method of Slatyer (1967) just before the stress relieving or stress-averting irrigation in all the treatments including the no-stress one. For this, terminal leaflet of the fourth leaf from the top of the randomly selected 10 plants in each plot were sampled between 10.30 and 11.00 a.m. The RLWC was calculated by the formula :

$$\text{RLWC} = (\text{FW} - \text{DW}) / (\text{TW} - \text{DW}) \times 100$$

Where, RLWC = relative leaf water content of leaf samples in per cent,

FW = fresh weight of leaf samples

DW = dry weight of leaf samples,

TW = turgid weight of leaf samples,

Plant height and dry weight of shoots and tubers were recorded before dehaulming on 5 and 8 January in the two years. After lifting the crop on 11 January 1979 and 17 January 1980 the produce was graded into 'ware' and 'seed' measuring > 50 mm and 25–50 mm, respectively. The estimation of total nitrogen in shoots in tubers was made by using the modified Kjeldahl method.

RESULTS AND DISCUSSION

The crop season of 1978–79 was characterised by mild temperatures but the 1979–80 season will long be remembered for much higher temperatures till the end of November (Table 2).

Table 2: Mean weekly maximum and minimum temperatures in the potato crop seasons of 1978–79 and 1979–80

Temp. (°C)	Week ending														
	30 Sept.	7 Oct.	14 Oct.	21 Oct.	28 Oct.	4 Nov.	11 Nov.	18 Nov.	25 Nov.	2 Dec.	9 Dec.	16 Dec.	23 Dec.	31 Dec.	7 Jan.
Maximum 1978–79	32.2	32.5	32.7	32.2	31.0	30.2	28.0	24.7	25.9	23.0	23.8	25.9	20.6	20.9	21.8
1979–80	35.3	34.6	33.5	32.4	30.1	31.0	28.7	27.3	24.4	23.3	23.7	21.2	20.5	18.2	17.1
Minimum 1978–79	21.7	19.2	14.1	13.7	16.5	12.9	13.2	12.6	10.4	6.4	5.9	6.2	4.8	2.9	3.7
1979–80	19.8	20.3	18.2	15.7	14.8	14.9	13.3	11.7	9.8	20.3	7.4	6.2	6.3	7.6	5.6

The plants had shorter stature and produced less dry weight of shoots but more that of tubers at corresponding stages of development in the mild season of 1978–79 than in the warm season of following year (Fig. 1). The mild season favoured N-uptake too. Thus, tuber development and N-uptake were inversely related to temperature-induced shoot growth.

Response to severe water stress:

Despite large variations in the absolute rates of growth and N-uptake in the two crop seasons, the depressant effect of severe stress, irrespective of the stage at which it was imposed, on these aspects followed the same trends in both. The emerging differences consequent on the imposition of stress persisted even after its termination with resumed irrigation schedule, in plant height and shoot dry weight but widened with time in tuber dry weight as well as N-uptake to figure prominently in the end (Fig. 1). (The emerging differences could be detected clearly by plotting log values of tuber dry weight and N-uptake against observation stages). The differences amongst the successive spells of phasic stress were well reflected in plant height, less so in shoot dry weight and negligible in tuber dry weight and N-uptake. Plant height was most sensitive to stress at stage II followed by stage I. The effect of water stress involving decrease in RLWC by 12.5, 12.0 and 8.9% at the successive stages individually was aggravated when it was imposed repeatedly, as indicated by sharper and earlier deflection of curves representing this.

Severe water stress influenced total yield of potatoes and N-uptake in tubers (Table 3) much in the same way as tuber dry weight. A single spell of severe stress at stage I reduced seed yield by 3.20 and 3.27 t/ha and the number of seed tubers by 6.6 and 10.0/m² in the successive years. In conformity with observation of Hukkeri *et al.* (1), stolonification and tuber initiation is the critical stage for seed production and the number of seed size tubers. On the other hand, stress at stage III reduced 'ware' yields particularly in 1978–79. Stress at stage II, tended to depress seed yield and inhibited 'ware' yield. This is in accord with the effect of drought during tuber development under rainfed conditions in U.K. (4).

Table 3: Irrigation interval involving stress period and net CPE (CPE minus rainfall from previous irrigation) and RLWC just before stress-relieving irrigation in the single-stage water stress treatments

	M I	M II	M III	S I	S II	S III
(1978–79)						
Irrigation interval (No. of days)	14	11	15	21	18	25
Net CPE (mm)	28.2	27.4	29.6	44.7	44.4	42.3
(1979–80)						
Irrigation interval	11	11	14	16	17	24
Net CPE (mm)	33.2	32.9	25.9	48.6	47.9	38.9
RLWC (%)	81.6	85.1	86.1	72.8	76.0	79.7

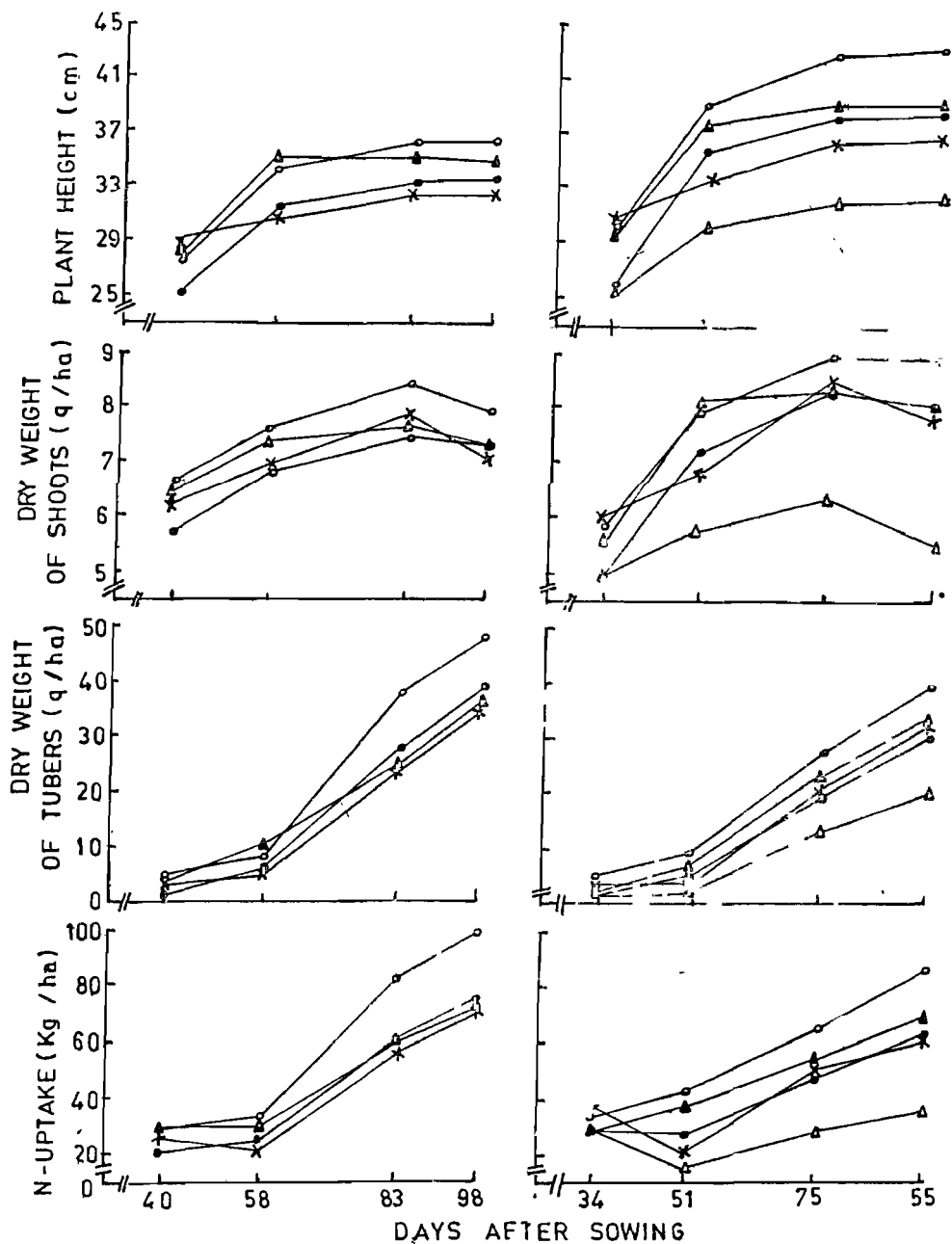


Figure 1: Plant height, dry weight of shoots and tubers and N-uptake as affected by water stress treatments:- 1. 000 (○—○), 2. S00 (●—●), 3. OS0 (*—*), 4. OOS (▲—▲), 5. SSS (△—△)

The deleterious effect of phasic severe water stress on growth and yields was accentuated when it was repeated. However, the cumulative effect of the recurring water stress on total yield and dry weight of tubers was not additive, being less than the sum total of the responses to stress at the individual stages. This suggests the operation of an adjustment mechanism under the conditions of intermittent stress.

Response to mild water stress:

In 1979–80, mild water stress involving decrease in RLWC by 3.7 per cent at stage I reduced seed yield significantly (Table 4). However, such stress at stage II or at stage III seemingly depressed 'ware' yield without affecting seed yield. Consequently, stress at any one stage tended to limit the total yield.

In 1978–79, when weather and stress conditions were milder than those in the succeeding year in the earlier stages, the effect of mild stress on growth, total yield and the grades of produce was not well pronounced. However, the cumulative effect of intermittent recurring mild stress was recorded on plant height, dry weight of tubers and N-uptake by tubers. The effects of mild stress on growth and yield of potatoes have been confirmed in a subsequent experiment by Sahota and Singh (3).

Table 4: Yield, number of seed tubers and N-uptake in the absence of water stress and responses to stress

Characters	No. of stress	Response to mild stress			Response to severe stress				S E Response	
		I	II	III	I, II & III	I	II	III		I, II & III
Total yield (t/ha)	18.16	+0.86	- 1.07	- 0.80	- 1.98	- 3.33*	- 3.70*	- 3.78*	—	0.91
Ware yield (t/ha)	6.13	+1.57	+ 0.69	- 0.23	- 0.38	- 0.12	- 1.21	- 2.62*	—	0.82
Seed yield (t/ha)	11.69	- 0.68	- 1.72	- 0.56	- 1.62	- 3.20*	- 2.48*	- 1.11	—	0.62
Number of seed tubers/m ²	23.2	- 1.1	- 1.9	+ 0.8	- 1.3	- 6.6*	- 2.6	- 2.3	—	1.0
N-uptake (kg/ha)										
Shoot	14.2	- 0.4	0.3	- 0.2	- 2.2*	- 1.7*	3.0*	- 2.3*	—	0.64
Tubers	85.0	+ 0.6	- 14.5	- 11.7	- 16.8	- 20	23	31.6	—	2.0
(1979–80)										
Total yield (t/ha)	14.14	- 1.71	1.54	- 1.33	- 2.00*	- 4.02*	- 3.93*	- 1.88*	- 6.65*	0.64
Ware yield (t/ha)	2.20	+ 0.04	- 1.02	- 0.79	- 0.50	- 0.78	- 1.37*	- 1.11*	- 1.48*	0.35
Seed yield (t/ha)	11.67	- 1.75	- 0.59	- 0.66	- 1.58*	- 3.27*	- 2.71*	- 0.77	- 5.25*	0.54
Number of seed tubers/m ²	36.0	- 3.3	- 0.9	1.6	- 3.5	- 10.0	- 4.9	- 0.8	- 12.9	1.40
N-uptake (kg/ha)										
Shoot	15.4	- 0.9	- 1.2	- 1.6	- 2.2	- 1.5	- 2.7	- 2.2*	- 6.7*	0.91
Tubers	67.9	- 9.4	- 9.0	- 1.7	- 11.1	- 16.2	- 16.4	- 13.6	- 37.8*	6.72

*Significant at 5% level

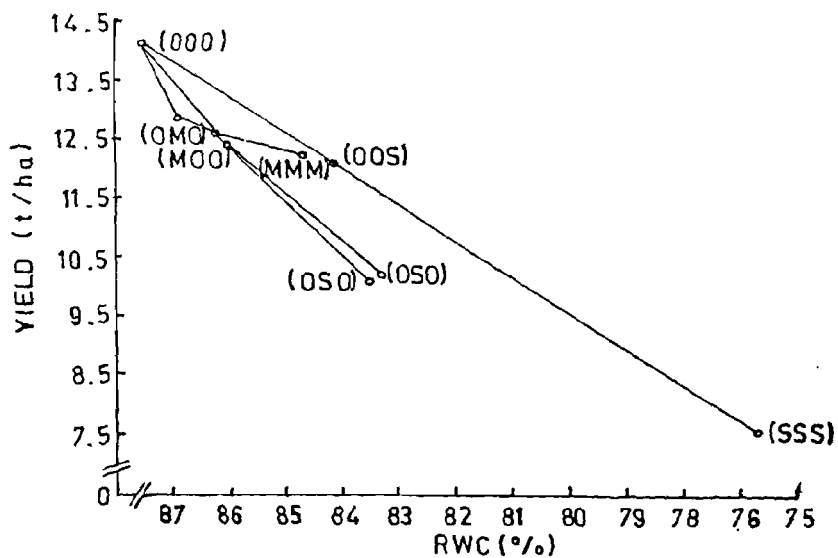


Fig. 2: Yield — RLWC relationship under repeated water stress stages

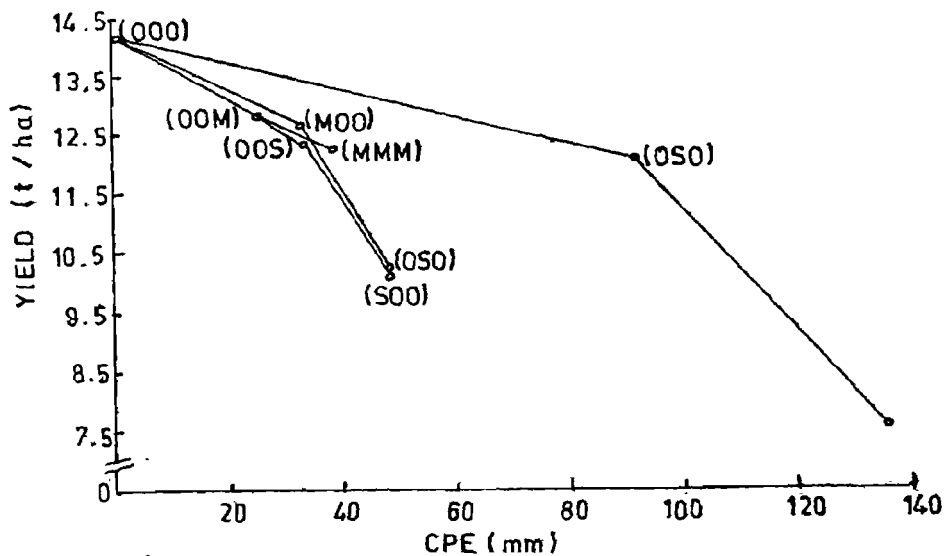


Fig. 3: Yield — net CPE relationship under repeated water stress stages

Relationship of RLWC and total yield:

Yield of potatoes fell steeply and linearly with the decrease in mean RLWC from 87.5 per cent under no stress to 75.7 per cent under repeated water stress (Fig. 2). The rate of fall was steeper per unit decrease in RLWC under stress at stage I or stage II. The curve relating yield to stress at stage III was hyperbolic. This may be partly ascribed to milder evaporative demands due to low temperatures as the crop advanced towards maturation. Thus, in general, yield was directly and linearly related to RLWC. Yield-net CPE relationship was understandably non-linear (Fig. 3). The same is to be expected in the case of yield-irrigation interval relation, in conformity with that connecting RLWC with irrigation interval as with net CPE.

CONCLUSIONS

One or the other phase of growth and tuberisation of potatoes is liable to be affected by water stress, depending on the time of its onset vis-a-vis a developmental stage. Tuber initiation is critical stage for the number of tubers (meristematic activity) and seed production, early tuber enlargement stage for stem elongation as well as for tuber size (extension growth) and late tuber enlargement stage for tuber size and 'ware' production, specially. Under conditions of assured water supply, the crop raised on loamy sand soils, should, therefore, be irrigated frequently, when CPE is between 15 to 25 mm for all round crop development and higher yield of seed as well as 'ware' potatoes consistent with economy in water expense. Under conditions of limited water supply, severe water stress must be avoided atleast at tuber initiation in the case of seed crops, and during tuber development in the case of crops for 'ware'. Of course, in a season of low evaporative demands and mild temperatures, the crop could withstand mild water stress, even if it recurs intermittently.

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EFFECT OF VIRAZOLE AND 2, 4-D ON THE GROWTH AND POTATO VIRUS X CONTENT OF POTATO LEAF CALLUS

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Abstract: Application of Virazole (Ribavirin) and 2,4-dichlorophenoxy acetic acid to the culture medium inhibited potato virus X (PVX) concentration in potato callus. Initiation and growth of callus were also affected due to Virazole and 2, 4-D mainly at 10 mg/l and 5 mg/l, respectively.

INTRODUCTION

Potato virus X (PVX) is an important virus infecting potatoes universally and the losses, in terms of tuber yield, have been reported to vary from 5 to 75% depending upon the virus strain, the cultivar and/or environmental factors, association with one or an other virus in the host (7).

The elimination of PVX from plants has been achieved by apical meristem tip culture (10, 13). Recently, callus culture has also been used to eliminate tobacco mosaic virus (TMV) from infected tobacco callus (8). Virazole (viricide) and 2, 4-D have also been tried and shown to be effective against PVX (1, 6, 12). The paper reports our data on the effects of Virazole and 2,4-D on the initiation and growth as well as virus-content of potato callus.

MATERIALS AND METHODS

Leaf discs (ca. 17 mg each) of potato cv. Kufri Chandramukhi (*Solanum tuberosum* L.), having 4–6 weeks old PVX infection, were inoculated (after surface sterilization) in the culture medium PM-2 (2) containing 3 mg/l NAA + 0.25 mg/l kinetin. The micropore filter sterilized Virazole and 2, 4-D solutions were added to the medium to obtain desired concentrations of 1, 5 and 10 mg/l and 1, 3 and 5 mg/l, respectively. The Virazole solution was added to the autoclaved medium, when the temperature of the medium was about 40°C. This was done to avoid degradation of Virazole due to autoclaving. The medium without Virazole and 2, 4-D served as control. The cultures were kept at 25 ± 2°C at 16 h light (3000 – 4000 lux) and 8 h dark condition. The fresh weight of callus was recorded after 8 weeks of incubation. Number of PVX local lesions, on at least 6 leaf-halves of *Capsicum pendulum*, were recorded on 5th day of inoculation using 100 mg of callus bits (ground in 0.9 ml of 0.1M phosphate buffer, pH 7.0) as the inoculum for each replicate/treatment.

RESULTS AND DISCUSSION

It is clear from the data (Table 1) that growth of potato leaf tissue calli was inhibited in all the treatments, though more significantly at 5 and 10 mg/l

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Table 1: Effect of virazole on the growth and PVX concentration of potato calli cv Kufri Chandramukhi

Virazole (mg/l)	Trial No	Av fresh wt of callus (mg)		PVX concentration	
		After 8 weeks	Average	Av no of local lesions	Average
0	I	310.3		90.8	
	II	324.6	317.4	62.3	76.5
1	I	216.5		50.1	
	II	233.5	225.0	40.6	45.3
5	I	161.8		24.0	
	II	179.6	170.7	17.0	20.5
10	I	159.7		9.3	
	II	151.6	155.7	7.8	8.5
		SEm	5.8	SEm	2.7
		CD (0.05)	16.1	CD (0.05)	7.5

Average number of local lesions with original PVX infected leaf = 180.

concentration of Virazole. Initiation of the callus was also delayed (required at least 20 days) due to these chemicals. However, even at a very low concentration of Virazole (1 mg/l), the calli initiated only after 15–18 days as compared to the control (7–10 days). The colour of the calli in case of control was white, green and brownish as compared to light or dark brown in media with Virazole except at 1 mg/l where a little part was also whitish. Virazole treatment, @ 5 and 10 mg/l, also resulted in a few necrotic spots on the leaf tissue (discs used as inoculum).

Concentration of PVX in the cultured tissue was also reduced at all three levels of Virazole tried as also in the control. Maximum reduction in PVX content was, however, observed at 10 mg/l followed by 5 and 1 mg/l Virazole. Though there was not much difference in growth of calli at 5 and 10 mg/l yet there was a significant reduction in PVX content of calli grown in the medium supplemented with 10 mg/l Virazole (Table 1).

Similarly, in 2, 4-D supplemented medium, growth of callus was poor at all the three levels tried (Table 2). The colour of the calli in control was greenish-white but their periphery was light brown, whereas the colour of the calli at 1 and 3 mg/l treatment of 2, 4-D was pale-green. At 5 mg/l treatment of 2,4-D, the calli were mostly light brown having a creamish tinge.

Maximum reduction in PVX concentration in callus was observed at 5 mg/l of 2, 4-D followed by 3 mg/l treatment. But in no case, the virus was eliminated from the calli. At 5 mg/l concentration of 2, 4-D, the calli were rather soft, loose friable than in control.

Table 2: Effect of 2, 4-D on the growth and PVX concentration of potato callus cv. Kufri Chandramukhi

2, 4-D (mg/l)	Tnal No	Av fresh wt of callus (mg)		PVX concentration	
		After 8 weeks	Average	Av. no. of local lesions	Average
0	I	301.5		70.8	
	II	322.5	312.0	66.6	68.7
1	I	277.8		56.5	
	II	292.8	285.3	61.1	58.8
3	I	264.1		46.5	
	II	276.3	270.2	42.3	44.4
5	I	210.5		33.3	
	II	183.1	196.8	25.3	29.3
		SEm	6.1	SEm	2.8
		CD (0.05)	16.9	CD (0.05)	7.8

Average number of local lesions with original PVX infected leaf = 180.

Addition of either Virazole (Rabavirin) or 2, 4-D into the culture medium resulted in a rapid decline in the concentration of virus mainly by way of suppression and also elimination of PVX within the callus.

Virazole has been observed to be both phytotoxic and viricidal (1, 5, 6). Schuster (11) also observed Virazole to cause severe damage to the virus-infected plants than the healthy ones indicating that Virazole treatment has positive interaction with host plant having virus infection. Similarly, Hariharsubramanian (4), Cheo (3), Simons et al. (12) have observed strong inhibitory effects of 2, 4-D on the infection and multiplication of TMV in the host *in vivo*. Growth hormones (NAA and kinetin) are also known to interfere with the virus content of the host due to their ability to affect the cell multiplication in the callus (9). Therefore, possibly 2, 4-D either suppresses PVX like NAA and kinetin, directly and/or inhibits the virus movement and consequent virus multiplication in the calli as it was observed to result in production of soft, friable callus.

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REACTION OF WILD *SOLANUM* SPECIES TO DIFFERENT VIRUSES

J. HORVATH¹

Abstract: In the course of studying the host-virus relations of thirteen wild *Solanum* species and twelve viruses we established 69 new relations. According to the examinations immune host-virus relation existed between *Solanum fernandezianum* and 5 viruses/belladonna mottle virus, cucumber mosaic virus, potato virus Y, tobacco necrosis virus and tomato ringspot virus. Hypersensitive, local reactions were given by 9 wild *Solanum* species to 3 viruses. Systemic susceptibility was shown by *Solanum fernandezianum* to alfalfa mosaic virus. The number of local and systemic host-virus relations was fifty-three.

Incompatibility and compatibility pointed out between wild *Solanum* species and viruses may be important in resistance breeding on the one hand, and in the ecology of viruses, on the other.

INTRODUCTION

Potatoes can be infected by more than 30 viruses (4, 7, 8, 18, 32). In recent years several new viruses pathogenic for potatoes have been described (e.g. potato virus T, potato virus U, potato virus V, wild potato mosaic virus, tobacco streak virus etc., or already known plant viruses (e.g. tobacco mosaic virus, tomato mosaic virus, cucumber mosaic virus, henbane mosaic virus) have been found pathogenic for potatoes (5, 14, 15, 18, 20, 21, 22, 24, 26, 30). Due to the most recent investigations the relations between the wild *Solanum* species and viruses occurring in the gene centres have become widely known (2, 3, 4, 9, 10, 16, 17, 27, 28, 31), though a more detailed knowledge of them requires further thorough investigations.

Our experiments were aimed at studying the responses of wild *Solanum* species originating from various gene banks to different viruses, and detecting new sources of virus resistance and new host-virus relations.

MATERIALS AND METHODS

The following viruses were used for inoculation: alfalfa mosaic virus, belladonna mottle virus, broad bean wilt virus, cucumber mosaic virus, potato aucuba mosaic virus, potato virus X, potato virus Y, tobacco necrosis virus, tobacco rattle virus, tobacco ringspot virus, tomato mosaic virus, tomato ringspot virus. Belladonna mottle virus and broad bean wilt virus do not belong to the specifically potato pathogen viruses. The reason why they were used in the experiments is that belladonna mottle virus is known to be markedly pathogenic for solanaceous plants and has recently been found to have a compatible host-virus relation with *Solanum ochroleucum* and *S. rostratum* (11, 17); while broad bean wilt virus as a polyphagous virus is wide-spread and has lately appeared in plants related with potato (e.g. *Capsicum annuum*) too (19, 29). As for the origin, maintenance and

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Table 1: Origin of the investigated wild *Solanum* species

<i>Solanum</i> species	Accession number*
<i>Solanum fernandezianum</i>	IS/C-1663/1981
<i>S. hermanni</i>	BIRM/S.0210
<i>S. khasianum</i>	IS/C-673/1982
<i>S. olgae</i>	IS/C-1013/1981
<i>S. ottonis</i>	IS/C-1672/1982
<i>S. panduriforme</i>	BIRM/S.1398
<i>S. platense</i>	BIRM/S.0738
<i>S. quitoese</i>	IS/C.578/1981
<i>S. rigescens</i>	IS/C 1024/1981
<i>S. saponaceum</i>	IS/C 1026/1981
<i>S. scabrum</i>	BIRM/S.0246
<i>S. sodomeum</i>	IS/C.1031/1981
<i>S. symonii</i>	BIRM/S.0797

*BIRM/S.: Birmingham *Solanaceae* Gene Bank, Birmingham, England; IS/C.: Index Seminum of the Botanical Garden, Copenhagen, Denmark.

characteristics of the viruses, detailed data are found in earlier papers (11, 12). The wild *Solanum* species examined (see Table 1) were inoculated by carborundum-spatula technique with water diluted (1:5 v/v) tissue sap from previously infected, virus-bearing host plants. After inoculation the plants were sprayed with water. Back inoculation from both the inoculated and non-inoculated leaves was carried out to indicator plants (12).

RESULTS

Immune host-virus relations: *Solanum fernandezianum* proved immune to belladonna mottle virus, cucumber mosaic virus, potato virus Y, tobacco necrosis virus and tomato ringspot virus.

Hypersensitive, local host-virus relations: Between nine *Solanum* species and three viruses hypersensitive host-virus relations were found (Table 2). The inoculated leaves showed necrotic lesions. The tobacco necrosis virus inoculated leaves of *Solanum ottonis*, *S. scabrum*, and *S. symonii* plants dropped following the appearance of local lesions. In the hypersensitive, local host-virus relations (Table 2) the viruses did not cause systemic infection to the plants, as checked by repeated back-inoculations.

Systemic host-virus relation: In our experiments one host-virus relation in which the virus could not be isolated from the inoculated leaves of the plants, only the non-inoculated leaves showed vein clearing and mosaic symptoms characteristic of virus infection. *Solanum fernandezianum* showed systemic susceptibility to alfalfa mosaic virus. From the inoculated leaves of the plant the virus could not be reisolated.

Local and systemic host-virus relations: In the course of studying the relations of wild *Solanum* species and various viruses different types of the local and systemic host-virus relation were established (Table 3). Latent local and systemic

Table 2: Local or hypersensitive host-virus relations

<i>Solanum</i> species	Viruses*
<i>Solanum fernandezianum</i>	TRSV
<i>S. hermanni</i>	TNV
<i>S. khasianum</i>	TNV
<i>S. olgae</i>	TNV
<i>S. ottonis</i>	TNV
<i>S. quitoense</i>	TNV
<i>S. rigescens</i>	TNV
<i>S. scabrum</i>	TNV
<i>S. symonii</i>	TNV, TRV

*TNV: tobacco necrosis virus, TRSV: tobacco ringspot virus, TRV: tobacco rattle virus.

Table 3: Local and systemic host-virus relations

<i>Solanum</i> species	Type of reaction*, **			
	(1)	(2)	(3)	(4)
<i>S. fernandezianum</i>	BBWV, PAMV PVX, TRV	ToMV		
<i>S. hermanni</i>		PVX		
<i>S. khasianum</i>		PAMV	PVX, PVY	
<i>S. olgae</i>	PVX, TRV		PVX, PVY	TRV
<i>S. ottonis</i>		BMV	AMV, CMV PAMV, PVX PVY, TRV ToMV, ToRSV	
<i>S. panduriforme</i>			PVX	
<i>S. platense</i>			PVY	
<i>S. quitoense</i>			AMV, PAMV, PVX, PVY, TRV	
<i>S. rigescens</i>			PVX, PVY	
<i>S. scabrum</i>			PAMV, PVX, PVY, TRV	
<i>S. saponaceum</i>			PAMV, PVX, PVY, TRV	
<i>S. sodomeum</i>		PAMV, PVX, TRV		
<i>S. symonii</i>			AMV, BMV, BBWV, CMV, PVY, TRSV, ToRSV	PAMV, PVX, ToMV

*Type of reaction: (1) Symptomless infection, (2) Symptomless local infection and vein clearing and mosaic symptoms on the non-inoculated leaves, (3) Chlorotic-necrotic local lesions and systemic mosaic symptoms, (4) Necrotic local lesions and systemic necrotic symptoms.

**AMV: alfalfa mosaic virus, BBWV: broad bean wilt virus, BMV: belladonna mottle virus, CMV: cucumber mosaic virus, PAMV: potato aucuba mosaic virus, PVX: potato virus X, PVY: potato virus Y, TRV: tobacco rattle virus, TRSV: tobacco ringspot virus, ToMV: tomato mosaic virus, ToRSV: tomato ringspot virus.

susceptibility was shown by the *Solanum fernandezianum* and *S. pigmae* to four and two viruses, respectively. Latent local susceptibility and manifest disease (vein clearing and mosaic) was pointed out in the relation of five *Solanum* species and five viruses (Table 3). Manifest local (chlorotic-necrotic lesions) and manifest systemic (vein clearing and mosaic) diseases were found to be caused by eleven viruses to eleven wild *Solanum* species (Table 3). Some of the local and systemic host-virus relations were characterized by necrotic lesions appearing both on inoculated and non-inoculated leaves. This type of host-virus relations was observed between *Solanum olgae* and tobacco rattle virus, further, between *S. symonii* and potato aucuba mosaic virus, potato virus X and tomato mosaic virus.

CONCLUSIONS

Between 13 wild *Solanum* species and 12 viruses 69 new host-virus relations were detected. Among the new research results particularly important is the immunity of *Solanum fernandezianum* from cucumber mosaic virus and potato virus Y. The exposure of local and/or hypersensitive host-virus relations between various wild *Solanum* species and tobacco necrosis virus may also be essential from the point of view of practice, since tobacco necrosis virus is known to be incompatible relation with certain potato varieties (e.g. Duke of York, Sieglinde; 7, 25). Remarkable is the complex hypersensitivity of *Solanum symonii* to tobacco necrosis and tobacco rattle viruses.

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YIELD STABILITY ANALYSIS OF SOME POTATO VARIETIES*

O.P. PATEL¹, K.N. MAURYA, K.C. DUBEY AND K.C. DABRAL

Abstract: The yield stability parameters α and λ in a trial on potato varieties revealed that the highest yielder did not possess the stable yield ability and the lower yielder possessed relatively stable statistics. The new high yielding variety "E 4451" was found to be considerably stable. The locally adapted variety "Patna Red" appeared to be the most stable variety, although its yield was considerably low. Hence the variety "E 4451", "F 5134" and K. Chandramukhi is found to be safe enough to be recommended for obtaining high as well as stable yields under Satpura plateau.

INTRODUCTION

Rankings of the varieties of crop plants exhibit considerable variation when tested over several environments. Decision regarding the choice of most suitable variety for a given agro-climatic region, therefore, becomes very much difficult. It has been demonstrated that those genotypes which exhibit less interaction with environments are relatively more stable in their performance. Plaisted and Peterson (4) and later on Eberhart and Russell (2) developed methods to evaluate the stability of genotypes. Tai (6) modified method proposed by Eberhart and Russell (2) and employed it to identify stable varieties of potato. Present investigation is an attempt to identify stable genotypes of potato for Chhindwara region of Madhya Pradesh, where potato is cultivated on large scale.

MATERIAL AND METHODS

Eight varieties of potato including the local check (Patna Red) were planted in rabi season in a randomised block design with four replications at JNKVV Research Station, Chhindwara for four years viz., 1971, 1972, 1973, and 1974. Plot size comprised of 4 rows 2.80 m long spaced 60 cm apart. Within rows tubers were planted 20 cm apart. Observation was recorded on marketable tuber yield/plot in kgs. Pooled analysis was performed following Cochran and Cox (1) after testing the homogeneity of error variance by Bartlett's test of homogeneity of variance quoted by Panse and Sukhatme (3).

RESULTS AND DISCUSSION

The homogeneity test of error variance was non-significant at 1 per cent level of probability. The table and calculated values were 11.345 and 10.172 respectively at X^2 (3 d.f.). Thus the results were pooled over from an individual year to obtain a combined estimate of the error variance.

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Variation for interaction between genotypes and environment was partitioned by Eberhart and Russell (2) into two components viz., linear response of genotypes to varying environments, being measured in terms of environmental indices and the pooled deviations representing deviation in performance of a genotype expected on the basis of regression. Since accurate measurement of environmental effects may not be possible, Tai (6) proposed a modification of Eberhart and Russell's (2) method which does not involve separation of interaction component into two components.

Mean squares for varieties and variety x year were highly significant (Table 1). This significance implied significant genetic differences among the 8 potato varieties for tuber yield and differential response of potato varieties to fluctuations in environments. Present results are in agreement with those reported by Sawant and Mandloi (5)

According to Tai (6) parameters could be employed to measure the stability in performance viz., α ; and λ ; which measure the linear response of its variety and deviation from linear response in terms of the magnitude of error variance respectively. Tai (6) defines a variety as average in stability which has values of 0 and 1 for α and λ respectively [$b_1=1$ and $Sd^2_i=0$ (2)]. On the other hand, a genotype would be considered as perfectly stable if the values for α and λ are -1 and 1 respectively. Thus none of the varieties proved to be perfectly stable.

The distribution of α and λ values of varieties including check are shown in Fig.1. Although Kufri Sindhuri recorded highest marketable tuber yield, it could be categorised as least stable since the values of two parameters viz., α and λ were +0.8309 and 0.3231 (Table 2). On the other hand, local check could be regarded as considerably stable in performance, as it is located in the above average stability region (Fig. 1). Nevertheless it happened to be the poorest yielder. The varieties E 4451, F 5134, Kufri Chandramukhi, and E 3797 were distributed in the average stability region. Kufri Chandramukhi and E 3797 were low yielder whereas the variety E 4451 and F 5134 ranked 2nd and 3rd in yield. The variety C 3721 gave considerable tuber yield however, this genotype exhibited considerable deviation from expected performance measured as λ . The value of α and λ of Kufri Chamatkar were similar to that of Kufri Sindhuri. Eberhart and Russell (2) describe a genotype as stable for which $\alpha = 0$ and $\lambda = 1$ in addition to high mean performance. Farmer

Table 1: Combined analysis of variance for marketable tuber yields (q/ha)

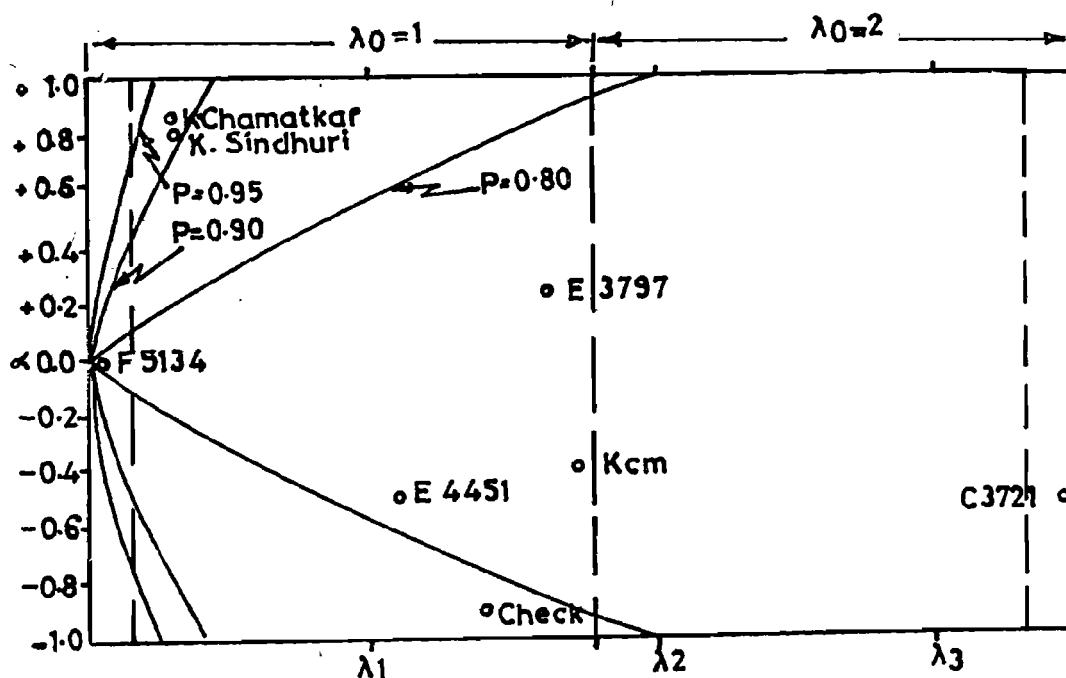
Source	d.f.	M.S.S.
Years	3	28037.6**
Replications within year	12	1735.2
Varieties	7	23150.7**
Variety x Year	21	3571.2**
Error	84	1057.4

**Significant at 1 per cent level.

Table 2: Marketable tuber yield (q/ha) of different potato varieties and stability parameters (α and λ)

Variety	Av. Yield	α	λ
C 3721	193 ^{d*}	-0.5197	3.5116
E 3797	202 ^{cd}	+0.2463	1.6231
E 4451	259 ^{ab}	-0.4788	1.0615
F 5134	247 ^{bc}	+0.0166	0.0148
Kufri Chandramukhi	189 ^d	-0.3904	1.7496
Kufri Chamtkar	208 ^{cd}	+0.8482	0.2941
Kufri Sindhuri	275 ^a	+0.8309	0.3231
Local (Patna Red)	168 ^d	-0.8805	1.4348

*Values followed by the similar letter in the yield column do not differ significantly as judged by the Duncan's New Multiple Range Test.

**Fig. 1:** Distribution of stability statistics

would not accept any variety, how so ever stable in performance, if it is a poor yielder. It appears that E 4451, F 5134 and Kufri Chandramukhi are relatively desirable genotypes.

The delayed tuberization phase in the varieties Kufri Sindhuri and Kufri Chamatkar which are medium to late, under unfavourable conditions may be the cause of unstable yield. The profuse vegetative growth of Kufri Sindhuri may be at the cost of tuberization under the adverse conditions.

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PHYSIOLOGICAL EVALUATION OF POTATO CULTURES

RAM PRATAP SINGH¹ AND RAJ PAL SINGH²

Abstract: Physiological evaluation of potato cultures revealed significant differences in the leaf area, leaf area index, specific leaf area (SLA), relative growth rate (RGR) and net assimilation rate (NAR) of potato cultures studied under Pantnagar (Nainital) conditions. All these characters varied with cultures and showed a decreasing trend with time in all the cultures. The magnitude of decline also differed from culture to culture. Leaf area and leaf area index reached their maximum at 60 days stage in Kufri Badshah in both the years. SLA, RGR and NAR were comparatively higher in Kufri Dewa at different stages than in other cultures.

Cultures like JH 222, JF 27 and Kufri Badshah, which developed optimum leaf area and leaf area index at early stages, also yielded more than those which had higher leaf area index at later stage like Kufri Sindhuri.

INTRODUCTION

Yield is a product of many physiological processes occurring in various plant parts at different times. Differences in yield potential could arise from any one or more of the physiological processes like net assimilation and finally translocation of photosynthates and nutrients from sources to sink. Power *et al.* (8) also concluded that plant growth and development are integral results of many factors operating both within and outside the plant. Among the most promising approaches to growth analysis are the concept of net assimilation rate, specific leaf area and relative growth rate. Banerjee *et al.* (2) observed that as minimum requirement for tuber initiation in Kufri Chandramukhi, leaf area should be 186.6 cm². Rate of dry matter accumulation and tuber bulking were similar in those treatments in which leaf area index (LAI) was maintained at or above 3 for two three weeks (4). Sharma *et al.* (11) recorded higher tuber yield in potato variety EM/B-81 because of high LAI in early stage and yields were lowest in Kufri Sindhuri because of low LAI in early stage and high LAI in the late stage. Relative growth rate of tubers and whole plants has been found highest between 35 and 44 days after planting and then decreased (6). Purohit and Malhotra (10) did not find definite pattern of variation in net assimilation rate of potato varieties at Jallundar with advancement in time.

MATERIALS AND METHOD

Field experiments were conducted during winter season of 1981–82 and 1982–83 on clay loam and sandy loam soils at Horticultural Research Centre, Patharchatta of G.B. Pant University of Agriculture and Technology, Pantnagar (Nainital) to measure the various physiological factors of plant system and their influence on tuber yield of potato cultures. There were twenty cultures replicated

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three times in a randomised block design, having 160 plants in each plot (90 plants in net plot). A basal dressing of 120 kg N, 80 kg P₂O₅ and 80 kg K₂O/ha was given to the crop through urea, single super phosphate and muriate of potash, respectively.

The crop was planted on 22nd and 24th October in both the years, respectively. Mancozeb (Dithane M-45) and methyl dimeton 25% E.C. (Metasystox) were sprayed to save the crop from late blight and sucking insects. Leaf samples were collected at three stages of the crop growth to measure the various physiological factors.

RESULTS AND DISCUSSION

Leaf Area: The leaf area per plant increased with the age of the crop and reached maximum at 60 days stage. In both the years Kufri Badshah maintained leaf area more than 100 cm² at 60 days stage. Beside this JF 27, JI 5857, K. Jyoti × G 2524 (6) also maintained higher leaf area at this stage as compared to other cultures (Table 1). In general leaf area of different cultures during the first year was higher. However, some cultures like Kufri Chandramukhi and JF 65 were poorer in this

Table 1: Leaf area per plant of potato cultures at different stages of crop growth during 1981–82 and 1982–83

Cultures	Leaf area/plant (dm ²)					
	1981–82			1982–83		
	Days after planting			Days after planting		
	45	60	75	45	60	75
C ₁ 7590	50.8	84.9	59.9	57.8	70.7	87.1
C ₂ G 2524	63.4	71.2	69.9	54.7	62.2	56.0
C ₃ F 6787	41.2	43.8	42.5	50.1	66.2	59.6
C ₄ JF 27	82.2	103.8	70.3	67.0	94.0	73.3
C ₅ JF 65	59.9	81.2	67.2	31.3	49.1	39.2
C ₆ JF 246	65.4	60.4	69.9	54.6	71.9	67.4
C ₇ JF 5106	62.7	85.3	69.1	55.7	60.8	61.3
C ₈ JH 49	50.5	55.0	51.0	46.1	69.7	62.9
C ₉ JH 222	80.8	110.8	93.0	52.2	63.5	62.5
C ₁₀ JI 5857	68.1	101.0	90.0	66.7	67.5	74.3
C ₁₁ Kufri Badshah	86.9	129.3	98.6	82.1	105.5	88.5
C ₁₂ Kufri Chandramukhi	40.0	42.7	36.5	41.8	51.3	33.2
C ₁₃ Kufri Dewa	48.1	80.4	56.8	63.3	70.7	77.9
C ₁₄ Kufri Jyoti X CP 1787 (2)	40.3	49.1	59.4	29.7	48.9	41.5
C ₁₅ Kufri Jyoti X CP 1787 (9)	50.1	58.5	54.5	60.4	75.4	64.2
C ₁₆ Kufri Jyoti X G 2524	59.8	86.7	73.7	68.4	93.5	61.1
C ₇ Kufri Jyoti X G 2524 (7)	44.8	73.2	58.2	54.4	60.2	39.4
C ₁₈ Kufri Sindhuri	59.1	121.7	90.4	53.6	71.8	86.9
C ₁₉ SLB/Z-569	61.1	80.4	66.3	51.1	59.0	56.2
C ₂₀ Ultimus	68.3	84.4	71.8	48.8	86.1	66.2
CD at 5%	3.8	5.9	5.1	6.6	7.6	7.1
G.M.	59.2	80.2	67.4	54.5	70.9	62.8

respect at all stages of crop growth. Similar to these findings, Zrunt (12), Allen and Scott (1) also reported that leaf area varied markedly from year to year and variety to variety.

Leaf Area Index (LAI): Similar to leaf area, LAI also reached maximum in all the cultures at 60 days stage. However, at 75 days stage there was reduction in LAI of all cultures with reduction in plant density. At 45 days stage C₁₅ was the best followed by C₁₁ while C₂₀ was poorest. Highly significant differences among various cultures were observed at 60 days stage also and Kufri Sindhuri (C₁₈) showed its superiority in this respect (table 2).

Some more cultures, which also maintained higher LAI at this stage, were C₁₁, C₁₅, C₁₉, C₁₆, C₁, C₁₇ and C₂₀. Maity and Chatterjee (7) also observed that LAI reached maximum at 60 days after planting indicating accelerated and early crop growth. Banerjee *et al.* (2) also reported that LAI increased till 56 days after planting in autumn.

Table 2: Leaf area index of potato cultures at different stages of crop growth during 1981-82 and 1982-83

Cultures	Leaf area/plant (dm ²)					
	1981-82			1982-83		
	Days after planting			Days after planting		
	45	60	75	45	60	75
C ₁ 7590	4.78	5.37	3.90	4.60	5.16	3.46
C ₂ G 2524	3.82	5.11	3.50	3.62	4.83	3.05
C ₃ F 6787	4.44	4.84	3.44	4.04	4.42	3.29
C ₄ JF 27	4.32	5.12	3.95	4.08	4.93	3.75
C ₅ JF 65	3.74	4.77	4.86	3.30	4.53	4.41
C ₆ JF 246	3.31	4.99	4.21	3.31	4.68	3.93
C ₇ JF 5106	3.84	5.03	4.74	3.80	4.02	3.30
C ₈ JH 49	4.17	5.18	4.20	3.57	5.02	3.02
C ₉ JH 222	3.61	4.66	3.80	3.64	4.44	3.35
C ₁₀ JI 5857	4.30	5.13	4.01	4.18	4.93	3.99
C ₁₁ Kufri Badshah	5.19	6.37	4.94	4.72	6.28	5.05
C ₁₂ Kufri Chandramukhi	3.80	4.91	2.98	3.43	4.94	3.06
C ₁₃ Kufri Dewa	3.50	5.31	4.35	3.42	5.11	4.27
C ₁₄ Kufri Jyoti X CP 1787 (2)	3.44	3.96	3.57	3.21	3.80	3.08
C ₁₅ Kufri Jyoti X CP 1787 (9)	5.45	5.95	4.67	4.97	5.77	4.30
C ₁₆ Kufri Jyoti X G 2524 (6)	4.22	5.74	5.02	3.94	5.67	4.98
C ₁₇ Kufri Jyoti X G 2524 (7)	4.86	5.50	3.88	4.53	5.00	3.08
C ₁₈ Kufri Sindhuri	3.89	6.51	5.38	3.95	6.29	5.06
C ₁₉ SLB/Z-569	3.78	5.79	4.07	3.03	5.25	3.55
C ₂₀ Ultimus	2.99	5.43	4.09	3.03	5.25	3.55
CD at 5%	0.10	0.10	0.09	0.08	0.07	0.09
G.M.	4.07	5.29	4.15	3.83	5.09	3.80

Specific Leaf Area (SLA): It would be observed from Table 3 that C₁₃ showed significantly highest SLA followed by C₁₁, C₉ and C₁₀. At 60–75 days stage a decline in SLA was recorded with minimum in C₃ surpassed by C₁₂. During the second year again C₁₃ developed the highest SLA followed by C₁₆, C₁₉ and C₁₇, while C₈ developed minimum SLA at both stages.

Relative Growth Rate (RGR): Potato cultures differed significantly in their RGR (Table 3). RGR was the highest in C₁₃ at both stages followed by C₁₁. It was also observed that in some cultures RGR was higher at the first stage indicating rapid bulking of tubers as in C₁₁, C₂ and C₁₈ while in others, it was higher at the second stage. During the second year RGR, in general, was higher at the first stage being highest in C₁₈ followed by C₇, C₈ and C₁₄. RGR was recorded very low in C₁₂ at both stages during both years. After tuber initiation RGR at early stages was higher and then declined with time (10). In this case also the differences in the peaks of

Table 3: Specific leaf area and relative growth rate of potato cultures at different stages during 1981–82 and 1982–83.

Cultures	Leaf area ratio (dm ² /g)				Relative growth rate(g/g/day)			
	1981–82		1982–83		1981–82		1982–83	
	45–60	60–75	45–60	60–75	45–60	60–75	45–60	60–75
C ₁ 7590	1.06	0.95	1.32	1.14	0.007	0.018	0.034	0.014
C ₂ G 2524	1.35	1.00	1.24	0.95	0.024	0.023	0.031	0.008
C ₃ F 6787	0.88	0.69	1.10	0.98	0.004	0.029	0.015	0.011
C ₄ JF 27	1.68	1.69	1.38	0.92	0.018	0.021	0.031	0.027
C ₅ JF 65	1.45	1.11	1.27	0.93	0.027	0.017	0.036	0.021
C ₆ JF 246	1.12	0.78	1.22	0.97	0.020	0.037	0.031	0.012
C ₇ JF 5106	1.75	1.32	1.27	0.85	0.008	0.034	0.051	0.034
C ₈ JH 49	1.15	0.75	1.05	0.85	0.012	0.042	0.049	0.003
C ₉ JH 222	1.88	1.39	1.27	0.90	0.015	0.033	0.026	0.031
C ₁₀ JI 5857	1.68	1.34	1.19	0.96	0.009	0.039	0.026	0.010
C ₁₁ Kufri Badshah	2.00	1.64	1.37	1.13	0.021	0.013	0.023	0.008
C ₁₂ Kufri Chandramukhi	0.84	0.71	1.24	0.95	0.007	0.010	0.009	0.012
C ₁₃ Kufri Dewa	2.17	1.15	1.72	1.40	0.037	0.053	0.031	0.011
C ₁₄ Kufri Jyoti X CP 1787 (2)	1.14	0.91	1.33	0.92	0.011	0.043	0.047	0.024
C ₁₅ Kufri Jyoti X CP 1787 (9)	0.97	0.82	1.10	0.84	0.009	0.019	0.027	0.013
C ₁₆ Kufri Jyoti X G 2524	1.47	1.23	1.50	0.97	0.008	0.028	0.038	0.015
C ₁₇ Kufri Jyoti X G 2524 (7)	1.06	0.86	1.47	0.95	0.021	0.023	0.036	0.004
C ₁₈ Kufri Sindhuri	1.70	1.46	1.30	0.95	0.034	0.011	0.052	0.023
C ₁₉ SLB/Z-569	1.44	0.94	1.42	1.02	0.014	0.046	0.030	0.026
C ₂₀ Ultimus	1.49	1.05	1.39	1.21	0.006	0.043	0.020	0.016
CD at 5%	0.104	0.064	0.16	0.09	0.006	0.006	0.006	0.006
G.M.	1.41	1.06	1.30	0.99	0.016	0.029	0.032	0.014

RGR of different cultures might be due to the differences in time of tuber initiation. Decline in RGR with time has also been reported by Collins (4) and Ezekiel and Murti (5).

Net Assimilation Rate (NAR): Similar to other parameters, NAR of potato cultures was also significantly different from each other. NAR, in general, was low at 45–60 days stage and then increased rapidly being the highest in C₆ at both stages followed by C₁₃. It was lowest in C₁₆. NAR increased rapidly between 60–75 days stage and C₁₉ showed superiority over other cultures.

During the second year NAR of most of the cultures peaked at the first stage which decreased later on. Only few cultures like C₄, C₉, C₁₇ and C₁₉ showed higher NAR at the second stage. The possible reason of lower NAR at first stage during first year may be early emergence and higher fertility level of the soil which resulted in early vegetative growth. Collins (4) and Moorby (7) have reported that NAR declines with the time of maximum leaf area and finally increases as the leaf senescence starts.

Table 4: Net assimilation rate and tuber yield of potato cultures during 1981–82 and 1982–83.

Cultures	Net assimilation rate (g/dm ² /day)				Tuber yield (q/ha)	
	1981–82 DAP		1982–83 DAP		1981–82	1982–83
	45–60	60–75	45–60	60–75		
C ₁ 7590	0.007	0.018	0.026	0.012	315	302
C ₂ G 2524	0.018	0.023	0.025	0.009	313	278
C ₃ F 6787	0.005	0.043	0.014	0.012	237	343
C ₄ JF 27	0.011	0.018	0.024	0.030	312	351
C ₅ JF 65	0.018	0.015	0.029	0.022	130	177
C ₆ JF 246	0.018	0.048	0.027	0.012	312	253
C ₇ JF 5106	0.005	0.026	0.045	0.027	305	270
C ₈ JH 49	0.010	0.056	0.047	0.004	426	331
C ₉ JH 222	0.008	0.024	0.020	0.034	411	402
C ₁₀ JI 5857	0.005	0.029	0.022	0.011	322	344
C ₁₁ Kufri Badshah	0.011	0.008	0.017	0.008	383	390
C ₁₂ Kufri Chandramukhi	0.008	0.015	0.007	0.012	186	207
C ₁₃ Kufri Dewa	0.017	0.045	0.018	0.008	303	341
C ₁₄ Kufri Jyoti X CP 1787 (2)	0.009	0.048	0.036	0.026	289	218
C ₁₅ Kufri Jyoti X CP 1787 (9)	0.009	0.023	0.025	0.016	304	264
C ₁₆ Kufri Jyoti X G 2524 (6)	0.005	0.023	0.025	0.015	359	347
C ₁₇ Kufri Jyoti X G 2524 (7)	0.020	0.028	0.025	0.037	223	252
C ₁₈ Kufri Sindhuri	0.021	0.008	0.040	0.024	363	340
C ₁₉ SLB/Z-569	0.010	0.050	0.020	0.026	214	265
C ₂₀ Ultimus	0.004	0.041	0.014	0.014	209	270
C D at 5%	0.005	0.007	0.004	0.006	62	58
G.M.	0.011	0.029	0.025	0.015	296	297

Tuber Yield: It would be observed from Table 4 that cultures were significantly different for final tuber yield. Culture JH 222 produced maximum tuber yield during second year and JF 49 during first year. However, Kufri Badshah, Kufri Sindhuri and Kufri Jyoti × G 2524 (6) also produced higher tuber yield in both the years and the differences in many cases were non-significant. The cultures inferior than the first set were C₁₀, C₁₃ and C₁₄. The comparison of various cultures on the basis of consistency in the yield during the two years indicate the superiority of JH 222 over the remaining cultures.

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BIOLOGY OF COCCINELLA SEPTEMPUNCTATA IN CHHINDWARA

S.R. DHARPURE

Myzus persicae (Sulzer) is a serious pest of potato crop. Besides sucking cell sap it transmits potato viruses (4). During January and February 1983 the population of *M. persicae* on potato crop was much less as compared to previous so many years. While determining the causes responsible for such a low population of this aphid it was observed that an aphidophagous coccinellid, *Coccinella septempunctata* L. was found preying on it. This beetle is also reported feeding on *M. persicae* at Simla and Rajgurunagar (1, 2). At Rajgurunagar its population during January 1979 was reported to be 70 grubs/100 plants (2). It was, therefore, thought to study the biology of this potential predaceous beetle under the prevailing climatic condition of Chhindwara (Madhya Pradesh).

Eggs of the predator were collected from potato field in February 1983 to initiate the rearing. Rearing was done in the laboratory at room temperature. On hatching predaceous grubs were fed on the colony of *M. persicae*. A female laid about 50-55 yellowish oval eggs. The incubation period was 4-5 days. Hatching of the eggs was recorded upto 90 per cent. The first instar grubs were grey, elongate and measured 3.5 mm in length. Moulting of the first instar grub was observed within 48 hrs. Second instar grubs were elongate and measured about 5.2 mm in length. Their colour darken and became brownish. They moulted within 30 hrs. The third instar grubs measured 5.5 mm in length. They had a dark coloured body with a broad shield like structure on head regions. Next moulting took place within 60 hrs. The fourth instar grubs were almost similar with the previous instar, except the length which measured 7 mm. This stage lasted for only 36 hrs. and then fourth moulting took place. The mature fifth instar grubs were elongated, somewhat flattened, brightly coloured and covered with minute tubercles. They measured 8.5 mm in length. The fifth instar stage lasted for 8 days. The grubs shrunk a little 24 hrs prior to pupation. The pupae were brown in colour and measured 6.5 mm in length and 4 mm in width. The adult beetles emerged within 7 days of pupation. Longevity of beetles recorded ranged between 12 to 16 days in the laboratory. Single beetle on an average consumed 15 *M. persicae*/day.

It is evident from the table-1 that a single beetle in its larval period devoured as much as 1538 aphids. Besides, it is well known that adults are also the predator of aphids. Thus, *C. septempunctata* L. is an important predator of aphids and can wisely be utilized in biological control of *Myzus persicae*, a potential vector of potato viruses while raising seed potato crops.

Table 1: Average number of aphids consumed by different instars of *C. septempunctata*

Instar	Duration for each instar	Average number of <i>M. persicae</i> consumed
First	First 24 hrs.	25
	Next 24 hrs.	43
Second	30 hrs.	60
Third	First 24 hrs.	70
	Second 24 hrs.	77
	Last 12 hrs.	24
Fourth	First 24 hrs.	60
	Next 12 hrs.	34
Fifth	First day	110
	Second day	140
	Third day	150
	Fourth day	165
	Fifth day	180
	Sixth day	200
	Seventh day	140
	Eight day	60
Total		1538

Dey (3) has also reported the biology of *C. septempunctata* L. Durations of various instars and stages reported by him from Mainpuri are less as compared to Chhindwara which is attributed to the differences in climatic conditions and aphid hosts of two regions.

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SPROUTING, WEIGHT LOSS, INTERNAL SPROUTING AND LITTLE TUBER FORMATION IN LONG STORED POTATOES SUBJECTED TO REPEATED DESPROUTING

T.R. DAYAL AND K.P. SHARMA

Stored potatoes deteriorate in quality due to a number of reasons. These include weight loss, sprouting and formation of little tubers and internal sprouts. Such deterioration is pronounced when storage is done at relatively high temperature. Methods of overcoming these problems and prolonging the storage life of potatoes have been reported (8). Sprout suppressants used for prolonging the storage period have been reported to cause internal sprouting and little tuber formation (3, 4, 6). Successive desprouting of stored potatoes can be employed for harvesting sprouts for use in rapid multiplication techniques (2). The present study reports sprouting, weight loss and occurrence of internal sprouting and little tuber formation in tubers of 8 potato cultivars subjected to repeated desprouting after prolonged storage in a country store in the hills.

Hundred tubers each of 8 potato cultivars were selected from the hill harvest (Kufri) of October, 1982. These were stored in an ordinary room (at 3-4°C minimum and 6-8°C maximum during winter and 10-12°C minimum to 18-20°C maximum temperatures during summer months in hessian cloth bags until the 20th of May, 1983. At this time, the tubers were non-dormant and had some sprouts. The tubers were desprouted and weighed. They were then stored in wooden crates in single layers under natural diffused light and observations made on sprouting and weight loss the 30th, 60th and 90th day. On each day of observation, the tubers were weighed to determine per cent weight loss during the previous 30 days of storage, they were then desprouted and the weights of the sprouts and desprouted tubers noted. Maximum and minimum temperatures and relative humidity within the store were recorded during the period of the study. Observations on internal sprouting and little tuber formation were made on the stored tubers from the 90th day onwards.

Due to prolonged storage during this period from April-May onwards, excessive sprouting, shrinkage and wrinkling were observed in all varieties. Regarding sprout weight (Table-1), varieties Kufri Chandramukhi, Kufri Jyoti, Kufri Lalima and Kufri Sherpa produced maximum sprouts on 60th day and then exhibited a downward trend where as Kufri Lauvkar, Kufri Dewa and Kufri Badshah produced maximum sprouts on 30th day and the production of sprouts gradually declined from 60th day onwards. This showed two clear growth patterns; a normal and a skewed curve respectively; among these varieties. However, variety Kufri Bahar did not fall in any of the two categories with respect to behaviour of sprout production.

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Table 1: Sprout weight (g)/kg. of tubers and per cent weight loss in differnt varieties.

Vanety	Period of storage days					
	30 days		60 days		90 days	
	Sprout weight (g) per Kg. of tubers	Per cent weight loss during the previous 30 days	Sprout weight (g) per Kg. of tubers	Per cent weight loss during the previous 30 days	Sprout weight (g) per Kg. of tubers	Per cent weight loss during the previous 30 days
Kufri Chandramukhi	14.91	1.17	17.67	7.02	13.15	4.30
Kufri Jyoti	26.56	5.11	28.55	10.11	11.16	5.63
Kufri Lalima	11.50	2.16	13.84	6.53	14.05	5.74
Kufri Sherpa	8.75	5.20	13.46	6.71	11.33	4.57
Kufri Lauvkar	26.95	3.00	27.39	7.40	23.46	7.63
Kufri Bahar	13.88	2.77	14.27	4.52	13.61	5.59
Kufri Dewa	20.11	3.54	17.12	6.60	15.59	5.40
Kufri Badshah	22.95	4.12	24.29	9.43	9.75	2.79
Mean	18.20	3.38	19.57	7.29	14.01	5.20
Average Minimum temperature	13.7	—	10.4	—	12.0	—
Average Maximum temperature	18.6	—	16.0	—	16.5	—
Average Relative Humidity	71.7	—	90.2	—	75.0	—

The percent loss in weight (Table 1) on 30th day was maximum in varieties Kufri Sherpa, Kufri Jyoti and Kufri Badshah and the least in Kufri Chandramukhi, Kufri Lalima, on 60th day it was maximum again in Kufri Jyoti, Kufri Badshah and Kufri Lauvkar and minimum in Kufri Bahar and Kufri Lalima. On 90th day maximum per cent weight loss was observed in Kufri Lauvkar and minimum in Kufri Badshah. In four varieties viz. Kufri Chandramukhi, Kufri Jyoti, Kufri Lalima and Kufri Sherpa, the per cent weight loss was found to be directly proportional to sprout weight at 60 and 90 days of storage whereas in other varieties Kufri Lauvkar, Kufri Bahar, Kufri Dewa and Kufri Badshah it was not so. At the second desprouting which followed a period of higher humidity, (Table 1) the mean total of sprouts produced and per cent weight loss were higher. This confirms the findings of Singh and Srivastava (7). However, it did not remain so at later days. This might be due to senile nature of the tubers that had been already desprouted twice. After 90 days of storage period clusters of sprouts were observed in all varieties but they were more prominent in Kufri Chandramukhi, Kufri Sherpa, Kufri Bahar and Kufri Dewa. Internal sprouts and little tubers inside and outside the mother tubers ranging from 5g to 30g were also observed in these varieties.

The trend of per cent weight loss proportional to sprout weight in varieties Kufri Chandramukhi, Kufri Jyoti, Kufri Lalima and Kufri Sherpa confirms the findings of Wien and Smith (11) but in other four varieties it did not show such relationship. It

might be due to their different sprout growth patterns and diverse genetic make-up. The formation of internal sprouts and little tubers could be due to successive desprouting resulting in formation of a rosette of hard sprout clusters at the crown end of the tubers (10). It appears that the thick clustered growth of sprouts acts as an appressorium which forces initial penetration of the periderm by the hard ingrowing internal sprouts (5). Since the tubers for study in this case were kept in single layers and without sprout suppressants, the possibility of pressure from neighbouring tubers in the pile and inhibition of growth resulting in little tuber formation (9, 6) could be excluded. The only possible reason seems to be the successive desprouting of tubers and hard rosette formation and entry into the periderm of the mother tuber in the form of internal sprouts (1, 2).

The study revealed that internal sprouting and little tuber formation might take place even without pile pressure and use of sprout suppressants under prolonged storage conditions.

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CORRELATION OF SOME PLANT CHARACTERS WITH YIELD IN POTATO

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Potato is an important vegetable crop. The yield per plant was found significantly associated with the number of leaves, branches, fresh shoot weight per plant and shoot height (4, 7, 8). Positive correlation was observed between the number of tillers and leaves per plant with tuber yield (6). Positive relationship was found between leaf area index and tuber yield while net assimilation rate did not show any relationship with tuber yield (2) and had significant correlation with the yield of different grades of tubers (1). Potato tuber yield is the result of interaction of many plant characters which was studied here.

Field trials were carried out during winter season of 1981-82 and 1982-83 at Horticultural Research Centre, Patharchatta of G.B. Pant University of Agriculture and Technology, Pantnagar (Nainital). A basal dose of 120 kg N, 80 kg P₂O₅ and 80 kg K₂O per hectare was applied before planting. Twenty potato cultures (Table 1) were taken with three replications having 160 plants in each replicate in randomized block design. Planting was done in the third week of October in both the years. Observations on morphological, physiological and tuberization characters were recorded on 5 plants (1 meter row length) dug out from each bed in each replication and average values per plant were worked out.

Morphological characters: Among the morphological characters, plant height and shoot fresh weight at 60 and 75 days stage had significant positive correlation with the yield. However, number of shoots and number of leaves showed non-significant but positive association (Table 2). Per cent shoot dry matter had no

Table 1: Details of the cultures

S.No.	Cultures	Symbols	S.No.	Cultures	Symbols
1.	7590	C ₁	11.	Kufri Badshah	C ₁₁
2.	G 2524	C ₂	12.	Kufri Chandramukhi	C ₁₂
3.	F 6787	C ₃	13.	Kufri Dewa	C ₁₃
4.	JF 27	C ₄	14.	Kufri Jyoti x CP 1787 (2)	C ₁₄
5.	JF 65	C ₅	15.	Kufri Jyoti x CP 1787 (9)	C ₁₅
6.	JF 246	C ₆	16.	Kufri Jyoti x G 2524 (6)	C ₁₆
7.	JF 5106	C ₇	17.	Kufri Jyoti x G 2524 (7)	C ₁₇
8.	JH 49	C ₈	18.	Kufri Sindhuri	C ₁₈
9.	JH 222	C ₉	19.	SLB/Z-569	C ₁₉
10.	JL 5857	C ₁₀	20.	Ultimus	C ₂₀

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Table 2: Correlation coefficient between total yield (q/ha) and plant characters during 1981-82 and 1982-83

Plant characters	Days after planting	Correlation coefficients (r)	
		1981-82	1982-83
Plant height	60	0.569*	0.536*
	75	0.566*	0.642
Number of shoots	60	0.194	0.285
	75	0.219	0.318
Number of leaves	60	0.258	0.342
	75	0.305	0.395
Shoot fresh weight	60	0.478	0.610*
	75	0.507*	0.781*
Per cent shoot dry weight	60	-0.252	-0.206
	75	-0.259	-0.249
Number of stolons	45	0.003	0.689*
	60	0.147	0.652*
Stolon length	45	-0.151	-0.231
	60	-0.281	-0.137
Number of tubers	75	0.347	0.465*
	90	0.451*	0.566*
Tuber fresh weight	75	0.157	0.746*
	90	0.287	0.675*
Per cent tuber dry weight	60	-0.261	-0.246
	75	-0.019	-0.305
Yield of 'A' grade tubers	122	0.597*	0.646*
	122	0.913*	0.828
	122	0.516*	0.493*
	122	0.356	0.208
Leaf area	45	0.374	0.707*
	60	0.406	0.669*
	75	0.471*	0.715*
Leaf area index	45	0.207	0.372
	60	0.235	0.344
	75	0.313	0.306
Specific Leaf area	45-60	0.365	0.102
	60-75	0.423	0.190
Crop growth rate	45-60	0.053	0.308
	60-75	0.102	0.354
Relative growth rate	45-60	-0.196	-0.038
	60-75	-0.326	-0.017
Net assimilation rate	45-60	-0.072	-0.029
	60-75	-0.029	0.029

* Significant at 5%

correlation with the final tuber yield. This was in agreement with some of the results of Singh and Jain (8) and Singh (7) who found significant correlation between plant height and tuber yield.

Tuberization and grade-wise yield: In 1981-82, the number of tubers per plant at 90 days and yields of "A", "B" and "C" grade tubers (A-more than 7.5 cm,

B-5–7.5 cm., C-2.5–5.0 cm. and D-less than 2.5 cm. dia.) were found to be significantly correlated with the total yield. However, number of tubers at 75 days and tuber fresh weight at 75 and 90 days, showed only positive but highly significant correlation with yield in the second year. Similar to first year, yields of “A”, “B” and “C” grade tubers also showed significant association with total yield, indicating the greater contribution of ‘B’ grade tubers in the total yield (1). Similar to shoot dry weight, dry matter accumulation in the tubers also did not show any correlation with the final yield. Gaur (3) has also reported the correlation to be negative but low ($r = -0.29$) for tuber yield and per cent dry matter. Stolon’s length also showed negative correlation with respect to yield indicating that length of stolon is not of much importance in higher tuber yield.

Physiological characters: In the first year, leaf area at 75 days after planting was found to be significantly associated with the yield. However, leaf area at 45 and 60 days stage had positive but non-significant correlation. While in the second year it showed significant correlation with yield at all these three stages of crop growth. Leaf area index, leaf area ratio and crop growth rate showed only positive but non-significant correlation in both years. Relative growth rate and net assimilation rate were negatively correlated with the yield except net assimilation rate at 60–75 days stage during 1982–83 showed positive but very low correlation with the final yield. Similar results have also been observed earlier (5, 2). Thus, it becomes clear that the parameters like relative growth rate and net assimilation rate had no influence on the quantity of the harvested tubers.

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DEGENERATION OF POTATO VARIETIES IN WESTERN MAHARASHTRA

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Potato, a vegetatively propagated crop, is attacked by many contagious and aphid transmitted viruses. The virus incidence goes on increasing with each multiplication and there is progressive reduction in tuber yield (2). In western Maharashtra, two potato crops namely *kharif* (July to September) and *rabi* (November/December to January/February) are grown. The aim of this study was to determine the rate of virus increase and its effect on tuber yield in five potato varieties in this region where *rabi* planting is late (4) and aphid population becomes high in early stages of the crop (2, 7).

Fresh breeders' seed of five potato varieties namely Kufri Chandramukhi, Kufri Sindhuri, Kufri Jyoti, Kufri Badshah and Kufri Lalima was first planted in *rabi* 1981-82 in a randomised block design with four replications in two separate sets. Set I received Thimet @ 1.5 kg a.i./ha as soil application, Metasystox @ 1.5 ml/litre of water as foliar spray and roguing of severe mosaic virus infected plants, while set II did not receive these treatments. Produce of these two sets alongwith fresh breeders' seed (as control) was planted in *rabi* 1982-83 in the same fashion as in the preceding year. The incidence of viruses was recorded only visually.

Only severe mosaic (SM) was expressed during 1981-82 in the range of 2.7-9.3% in set I and 3.1-14.7% in set II, the lowest being 2.7-3.1% in Kufri Badshah followed by Kufri Jyoti (3.5-5.8%). Critical aphid level of 20 aphids per 100 compound leaves of 33 plants occurred after 38 and 46 days after planting in set I and II. Thus the crop was exposed to high aphid level for rest of the season (i.e. another 35-45 days). During 1982-83, both mild and severe mosaics were observed in var. Kufri Chandramukhi but SM alone was recorded in other varieties. Their incidence ranged from 1.2-81.3% in set I and 2.7-91.4% in set II being the highest in Kufri Chandramukhi (9-91.4%) followed by Kufri Lalima (11.3-45.7%) and the lowest (1.2-11.7%) Kufri Jyoti and Kufri Badshah. Critical aphid level crossed after 32 and 39 days after planting in set I and II, respectively. Though plant protection and roguing in set I resulted in a decrease in incidence of SM (1.3-36%) as compared to that in set II (2.7-45.7%), it was high (up to 45.7%) in both the sets in the seed carried from previous season as compared to fresh breeder's seed (up to 14%).

Plant protection and roguing of severe mosaic infected plants in set I gave lower (9-30%) reduction in tuber yield as compared to set II (15-42.8%). Yield reduction was maximum (18-42.8%) in set II in Kufri Lalima followed by Kufri Chandramukhi (19.1-30.8%) and minimum in set I (9.1-10.2%) in Kufri Jyoti and Kufri Badshah.

Incidence of potato severe mosaic was high (3.2-36.0%) after two exposures in western Maharashtra. In contrast the incidence of mosaics remained very low

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(1–8%) even after nine exposures during autumn (October–December) in NW plains (Jalandhar) (6). Rabi crop (November/December — January/February) in western Maharashtra is taken under high aphid population (2, 7) while autumn crop at Jalandhar is taken under very low aphid population level (4). On the other hand, spring crop (January–March) at Jalandhar is exposed to high aphid population level (4), like the rabi in western Maharashtra, and has high mosaics incidence in spring crop at Jalandhar (5, 6).

Reduction in the incidence of SM upon roguing and application of insecticides has been reported (1, 3). The effect was more apparent in Kufri Badshah and Kufri Jyoti as compared to other varieties. Yield reduction after second exposure in this study was 9–42.8%, but, lower than that was observed after 3 exposures during spring at Jalandhar (6).

Yield reduction was low (9–10%) in Kufri Badshah and Kufri Jyoti as compared to other varieties (13.4–30%) when produce from the previous season was planted using insecticides and upon roguing. Keeping in view the lower degeneration and less depression in yield in Kufri Jyoti and Kufri Badshah, as well as high seed cost in western Maharashtra, seeds of these varieties can be reused for two to three seasons economically.

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GROWTH OF POTATO VARIETIES DURING AUTUMN AND SPRING IN PUNJAB

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Pattern of growth and development of potato plants is influenced by environmental factors of which the day length and the temperature are more important (2, 4, 5, 8, 13). A lot of work has been done on the effect of different environmental factors on the growth and development of many Indian potato varieties (10, 11, 12, 14, 15), but the performance of varieties differing in rating from early to late maturing under different environmental conditions and physiological characteristics associated with them is not well documented. Thus a need for detailed studies on this aspect was felt. Results of field experiments conducted to investigate the influence of environment on the vegetative growth and yield of potato plants in north western plains of Punjab at Central Potato Research Station, Jalandhar are being reported, where two crops are raised in a year. The environmental characteristics for the spring crop (January-February to May-June) are increasing day length and temperature from planting to harvesting in contrast to the conditions during autumn crop (September-October to December-January).

Six commercial varieties and three advanced hybrids planted in the field in randomised block design with four replications (plot size 4.8 x 3.0 m) during autumn 1982 and spring 1983 were grouped as follows depending upon their growth behaviour during autumn.

Early maturing	Medium maturing	Late maturing
Kufri Chandramukhi	Kufri Lalima	Kufri Badshah
Kufri Bahar	Kufri Jyoti	Kufri Sindhuri
JN-1752	JN-2207	JH-222

Tubers of equal weight were planted as such during autumn and after giving triple treatment for breaking dormancy during spring. Normal cultural practices were followed for raising the crop. Weekly observations on tuber initiation, tuber number and weight/plant, number of stem and leaves/plant, longest stolon length and dry weight of different plant parts were recorded on two alternate plants in three even numbered rows in each plot. Daily record of maximum and minimum air and soil temperature, rainfall and sunshine was maintained throughout the experiment.

Tuber initiation and development: Tuber initiation started 26, 26 and 32 days, after planting (DAP) in early, medium and late maturing cultivars, respectively. During spring, due to prevailing long day conditions which are reported to delay tuberisation (1, 7) the tuber initiation was delayed to 49 days. A significant difference

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between early, medium and late maturing groups in both the seasons observed with respect to tuber initiation (Table 1 & 2) confirms the earlier reports of Sharma et. al. (12) that tuberisation is closely related to maturity. Different groups recorded significant differences with respect to the number of tubers/plant during spring, with late maturing group recording more numbers. The differences were however non-significant during autumn. Number of tubers/plant were increased by 12.6, 67.7 and 100% in early, medium and late maturing groups, respectively, during spring in comparison to autumn (Table 1 & 2).

The fresh weight of tubers/plant remained higher in the early maturing cultivars due to early tuberisation. Significant differences were recorded during spring with maximum yields in medium maturing and minimum in late maturing group. The differences were however, non significant during autumn. The differential behavior of groups in the two seasons are well explained due to the environmental conditions. During spring when the temperatures are increasing from planting to harvesting, the optimum temperatures for tuber development prevailed for a short duration for late maturing cultivars, which accounted for the lesser tuber weight. The fresh weight of tubers/plant in all the groups remained lower during spring (Table 1 & 2) confirming the earlier reports (14, 15) of slow tuber development under long day and high temperature conditions.

Table 1: Changes in morphological characters of potato during growth in autumn.

Group	DAP (days)	Tuber initiation (%)	Tuber number/plant	Fresh weight of tubers/plant	Stem number	Leaf number	Maximum stolon length (cm);
Early maturing	26	54.2	—	—	4.3	40.5	7.8
	32	100.0	—	—	—	—	—
	39	100.0	16.6	115.8	4.8	74.7	11.3
	53	—	15.2	366.4	5.0	93.4	10.9
	67	—	12.9	543.9	4.2	88.6	11.9
	84	—	16.2	833.3	5.2	67.5	11.0
	Mean	84.7	15.7	464.1	4.7	72.9	10.6
Medium maturing	26	29.2	—	—	4.0	42.5	7.8
	32	100.0	—	—	—	—	—
	39	100.0	15.5	77.5	4.0	94.1	14.6
	53	—	15.4	306.0	4.5	118.7	12.9
	67	—	12.5	545.2	3.5	102.5	13.1
	84	—	14.9	811.0	4.2	76.1	12.6
	Mean	76.4	14.6	434.9	4.6	86.8	12.2
Late Maturing	26	0	—	—	4.0	41.3	4.5
	32	83.3	—	—	—	—	—
	39	100.0	15.0	52.2	4.4	11.5	14.9
	53	—	13.2	247.3	3.7	29.3	11.5
	67	—	13.6	512.1	3.5	17.5	12.3
	84	—	14.1	833.0	4.0	32	12.9
	Mean	61.1	14.0	411.1	3.9	105.5	11.2
CD for groups		11.5	N.S.	N.S.	0.4	9.6	N.S.

Table 2: Changes in morphological characters of potato during growth in spring

Group	DAP (days)	Tuber initiation (%)	Tuber number/plant	Fresh weight of tubers/plant	Stem number	Leaf number	Maximum stolon length (cm)	
Early maturing	49	50.0	—	—	3.0	39.3	19.1	
	56	87.5	—	—	—	—	—	
	63	100.0	15.6	77.9	4.3	99.6	24.2	
	77	—	17.1	293.1	4.0	125.3	23.8	
	91	—	19.4	610.8	3.5	132.5	28.1	
	106	—	18.8	756.3	3.8	97.8	24.5	
	Mean	79.2	17.7	434.5	3.7	98.9	23.9	
Medium maturing	49	29.2	—	—	4.3	53.8	16.8	
	56	79.2	—	—	—	—	—	
	63	100.0	24.3	62.2	5.3	131.6	24.2	
	77	—	23.3	366.1	5.0	149.6	25.3	
	91	—	25.7	652.9	4.9	139.9	25.0	
	106	—	24.8	797.3	4.0	90.7	23.7	
	Mean	69.5	24.5	469.6	4.7	113.1	23.0	
Late maturing	49	12.5	—	—	5.0	61.3	16.6	
	56	54.2	—	—	—	—	—	
	63	100.0	21.0	18.2	5.6	162.2	25.6	
	77	—	29.8	252.5	5.5	210.5	24.7	
	91	—	29.0	480.0	4.7	222.4	23.6	
	106	—	32.9	627.9	4.6	187.9	24.2	
	Mean	55.6	28.2	344.7	5.1	168.9	22.9	
CD for groups			9.8	2.6	24.2	0.3	11.2	N.S

Development of stem, leaves and stolon: Significant differences existed between different groups with respect to the number of stem/plant with maximum number in early maturing groups followed by medium and the late maturing groups during autumn. The trend was reverse during spring. Lesser number of tuber/plant were recorded in groups with lesser number of stem/plant during the two crop seasons showing thereby a direct correlation between these two characters. (Table 1 & 2).

Groups differed significantly with respect to the number of leaves/plant with the maximum number of leaves in late maturing cultivars. This is perhaps due to preferential utilization of photosynthate in the addition of new leaves because of the non-availability of sink due to late tuberisation. 26–60% more number of leaves/plant recorded in all the groups during spring verify the earlier reports that long day conditions and high temperature favour more growth in the top (8, 15). The number of leaves increased upto 67 and 91 days during autumn and spring, respectively (Table 1 & 2). The continued growth of the top observed during spring season was apparently at the cost of tubers which initiated later and developed slowly due to long days (9, 10).

Differences between different groups with respect to maximum stolon length were non-significant showing that this character is not related to maturity of the

cultivar. An increase in stolon length upto 85–125% during spring in different cultivars (Table-1) is due to the effect of longer photoperiods as already reported (15).

Partitioning of dry matter in different plant parts: Partitioning of dry matter to stem leaves, roots and stolons decreased gradually to low values during growth in autumn but in spring due to late tuber initiation and hence the non-availability of sink the percentage of total dry matter in stem increased upto 63 DAP. The partitioning of dry matter to the tubers was just the reverse of that to the leaves and the values recorded a gradual increase during growth. The final values were 74.5, 71.4 and 76.8% during autumn and 77.7, 75.0 and 59.2% during spring in the early, medium and late maturing groups, respectively (Table-3). Low dry matter partitioned to the tubers in late maturing varieties during spring is well explained in terms of environmental conditions. Due to late tuberisation in the group, the optimum temperatures for tuber development prevailed only for a short duration.

Table 3: Percentage of dry matter in different plant parts of potato during growth.

Season	Group	DAP (days)	Stem	Leaves	Tuber	Stolon	Root	
Autumn	Early maturing	26	17.6	66.7	—	2.9	12.8	
		39	9.2	53.6	33.1	1.0	3.2	
		53	6.6	48.3	42.7	0.5	1.8	
		67	5.1	29.0	63.9	0.3	1.3	
		84	3.3	20.9	74.5	0.2	0.9	
	Medium maturing	26	14.9	63.4	—	2.8	14.7	
		39	14.7	57.4	19.8	2.0	4.9	
		53	8.9	51.5	36.1	0.9	2.6	
		67	6.1	26.2	66.2	0.4	1.4	
		84	4.7	22.3	71.4	0.4	1.3	
	Late maturing	26	17.0	65.7	—	2.3	15.1	
		39	14.4	62.8	16.2	1.7	4.8	
		53	12.5	42.0	41.8	0.7	2.9	
		67	8.1	27.0	62.6	0.4	1.6	
		84	6.2	22.0	76.8	0.3	1.3	
	Spring	Early maturing	49	10.8	73.6	1.0	4.1	10.3
			63	11.7	56.5	24.6	2.5	4.7
			77	8.2	32.8	55.1	1.2	2.7
91			7.1	19.0	71.6	0.7	1.5	
106			5.6	14.9	77.7	0.5	1.3	
Medium maturing		49	11.1	73.5	—	3.9	11.5	
		63	13.4	58.3	18.0	3.1	7.2	
		77	8.3	30.0	56.9	1.7	3.0	
		91	6.4	21.2	69.8	0.8	1.7	
		106	5.0	18.0	75.0	0.6	1.5	
Late maturing		49	13.1	72.9	—	2.7	11.3	
		63	18.8	65.1	5.0	3.7	7.4	
		77	16.9	36.5	41.9	2.2	4.1	
		91	16.7	25.2	54.0	1.3	2.6	
		106	14.3	23.0	59.2	1.0	2.3	

Meteorological data showed that environmental conditions were quite different during the two seasons (Fig. 1). Both air and soil temperatures showed gradual decrease during autumn but an increase was recorded during spring. More rainfall (mm) spread throughout the spring resulted in better moisture availability and higher air and soil temperature and longer day length favoured haulm growth and more dry matter production in the top as already reported by earlier workers (1, 3, 4, 6, 15).

The above studies suggest that in north western plains during spring crop when the temperatures and day lengths are increasing from 6.5° to 37.0°C and from 11.0 to 13.5 hours, respectively, only early and medium maturing potato varieties should be grown for higher dry matter partitioning to the tubers and hence higher yields.

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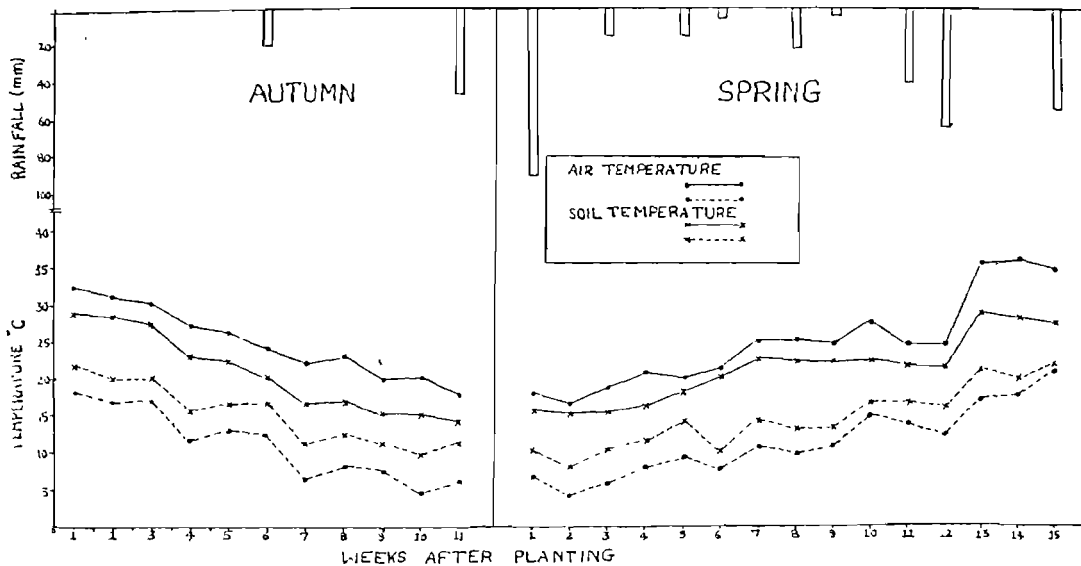


Fig. 1: Air and soil temperature and rainfall during the two crop seasons

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RESPONSE OF POTATO VARIETIES TO DIFFERENT ISOLATES OF *RHIZOCTONIA SOLANI*

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Screening of potato cultivars to different isolates of *Rhizoctonia solani* causing stem canker and dry rot diseases of potato has received a little attention. Shrivastava (3) reported a varying degree of pathogenicity of five isolates of *R. solani* on three varieties. Since then many new varieties have been introduced in cultivation and their response to this pathogen have not been evaluated. Pathogenicity experiments of twentyfour isolates of *R. solani* against five potato varieties were conducted in this study.

Five potato varieties viz. Kufri Chandramukhi, Kufri Chamatkar, Kufri Sinduri, Kufri Sheetman, and Kufri Jyoti procured from Potato research sub-station Daurala, Meerut and twentyfour pathogenic isolates of *R. solani* were selected. Out of these twentyfour isolates, eighteen were of anastomosing group 3 (AG 3), four of AG 4 and two isolates (R 21 and R 22) did not anastomose with any of the tester isolates. Pathogenicity of all the isolates was first tested in sterile sand on all the five varieties. In second set of experiments all these isolates were tested against three varieties viz. Kufri Chandramukhi, Kufri Chamatkar and Kufri Sinduri, the varieties which were commonly grown in Malwa region. Twenty one day old sand oatmeal culture of *R. solani* was mixed in sand/soil at 10% w/w in all experimental pots (30 cm x 24 cm) having three Kg of sand/soil. The pots after sowing were kept in glass-cage at 27°C and provided with artificial light (2200 Lux). Each pot was given 300 ml Knob solution (2) and water as and when necessary.

For dry rot disease, only four isolates of *R. solani* were tested against tubers of variety Kufri Chandramukhi. After surface sterilization, a cavity was made by removing a cylinder of 7 mm diameter, then a 7 mm agar disc from young colony of *R. solani* was inserted in the cavity and the tuber cylinder was replaced. The inoculated tubers were incubated in six dry and six moist chamber at 27°C with suitable control. At the time of recording, the lesions were categorized in five grades from healthy to severely damaged plants/tubers as follows:-

Plants:- 0—Healthy plants (no infection); 1—Lesions as water soaked areas on lower portion of stem, collar and stolon; 2—Moderate infection, retarded growth of plants, lesion became brown, slight browning of roots; 3—Severe infection, small yellow leaves on weak areal shoot, lesion became cankered and dark brown, severe browning of roots; 4—Very severe infection, girdling of collar, areal portion with small and yellow leaves, lesion remain cankered and deep brown.

Tubers:- 0—No rotting (healthy tubers); 1—Slight rot, one-fourth of tuber had changed to buff colour; 2—Moderate rot, half of the tuber had changed to light

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brown spongy mass; 3—Severe rot, more than half tuber converted to brown spongy mass; 4—Very severe rot, almost complete tuber had changed to brown corky mass.

Employing these grades, disease index was calculated by formula of Spencer and Fox (4). Data both from stem canker and dry rot were analysed for significant level ($P=0.05$) using Duncan's (1) Multiple Range Test.

All the twentyfour isolates of *R. solani* were pathogenic to the five varieties of potato (Table 1 and 2). In sand, maximum and minimum disease indices were in suscept-pathogen combination Kufri Chandramukhi—*R. solani* R 17 and Kufri Jyoti—*R. solani* R 25 respectively. In case of natural soil, the highest disease development was in Kufri Chandramukhi and Kufri Sindhuri infected by *R. solani* R 14. Separate statistical analysis of potato cultivars against 24 isolates of *R. solani* revealed that each cultivar responded differently with each isolates as regards susceptibility and disease development indicating that there were various strains of

Table 1: Pathogenicity of different isolates of *R. solani* causing stem canker in five potato varieties in sterile sand.

S. N.	Kufri Chandramukhi		Kufri Chamatkar		Kufri Sindhuri		Kufri Sheetman		Kufri Jyoti	
	I.No	D.I	I.No	D.I.	I.No.	D.I.	I.No.	D.I	I.No.	D.I
1	R 22	18.00a	R 25	12.60	R 9	24.00a	R 20	19.80a	R 25	12.00a
2	R 9	18.20a	R 24	20.00a	R 24	26.00a	R 25	20.00a	R 24	15.00a
3	R 23	22.22	R 9	21.50a	R 25	28.00a	R 18	22.50ab	R 9	16.90b
4	R 25	30.50	R 22	23.30	R 22	34.50b	R 24	25.00b	R 19	30.00b
5	R 7	34.30b	R 19	30.00b	R 23	35.50b	R 7	28.20c	R 23	31.10c
6	R 24	36.20b	R 18	32.50b	R 18	38.30c	R 21	29.10cd	R 10	33.30cd
7	R 21	37.50b	R 5	40.00c	R 20	40.00c	R 9	30.00cd	R 7	35.00de
8	R 18	40.00c	R 15	40.00c	R 16	43.20d	R 22	31.40de	R 13	37.00ef
9	R 15	41.50c	R 20	40.00c	R 17	44.40d	R 5	34.60ef	R 1	40.00fg
10	R 2	42.50c	R 12	42.00cd	R 15	47.70e	R 11	35.00f	R 16	40.00fg
11	R 20	48.30	R 13	43.00cde	R 11	48.00ef	R 16	36.00fg	R 12	43.30g
12	R 10	53.00	R 21	43.96def	R 19	50.00fg	R 19	38.10hi	R 11	44.00g
13	R 19	58.80	R 10	46.60ef	R 3	51.40gh	R 8	40.00ij	R 18	44.00g
14	R 11	62.50d	R 16	47.90fg	R 6	53.30hi	R 12	42.00jk	R 22	45.00gh
15	R 16	64.60de	R 23	51.10gh	R 12	55.00i	R 3	42.00jk	R 15	48.00hi
16	R 8	65.40e	R 14	52.00hi	R 7	55.30i	R 10	42.00jk	R 21	48.20hi
17	R 6	66.60ef	R 7	53.30hi	R 5	60.00j	R 23	43.00k	R 3	49.30ij
18	R 14	68.00f	R 1	54.00hi	R 10	60.00j	R 14	48.00l	R 14	50.00ij
19	R 13	68.00f	R 2	55.40i	R 8	60.80jk	R 6	49.00l	R 20	52.20j
20	R 1	73.30g	R 11	60.00	R 13	62.50k	R 13	52.50	R 6	53.30j
21	R 5	73.90g	R 3	66.00j	R 21	62.90k	R 1	57.70m	R 8	54.20j
22	R 3	80.00g	R 6	66.60j	R 1	66.60l	R 15	60.00mn	R 5	56.90j
23	R 12	80.00h	R 17	66.70j	R 2	68.60l	R 2	62.50no	R 2	60.00
24	R 17	81.60h	R 8	72.50	R 14	72.00	R 17	63.60o	R 17	65.70

I.No.—Isolate numbers

D.I.—Disease indices

Values followed by the same letter(s) are not significantly different according to Duncan's Multiple Range Test. ($P=0.05$).

Table 2: Pathogenicity of different isolates of *R. solani* causing stem canker on three varieties of potato in natural soil.

Kufri Chandramukhi			Kufri Chamatkar		Kufri Sindhuri	
S.No.	I.No.	D.I.	I.No.	D.I.	I.No.	D.I.
1	R 9	16.90a	R 25	10.80a	R 25	10.80a
2	R 22	17.10a	R 10	12.60a	R 7	11.40a
3	R 25	20.00ab	R 24	14.20a	R 20	15.00b
4	R 23	21.50b	R 9	17.10b	R 24	16.20b
5	R 21	21.50bc	R 19	18.00bc	R 5	20.00c
6	R 24	22.50cd	R 22	18.30bc	R 9	20.00c
7	R 7	26.20d	R 7	20.00bcd	R 15	20.00cd
8	R 15	28.00d	R 21	21.40cd	R 21	22.00cde
9	R 18	29.20d	R 15	21.50cd	R 22	22.90de
10	R 3	34.70e	R 5	21.70cd	R 23	24.30e
11	R 8	36.00ef	R 16	23.60d	R 16	25.70ef
12	R 16	36.70ef	R 18	27.50e	R 19	28.00f
13	R 20	37.50ef	R 12	28.60e	R 2	31.10g
14	R 2	40.00fgh	R 2	29.20e	R 10	31.30g
15	R 11	40.00fgh	R 20	30.00e	R 8	35.00
16	R 5	41.50gh	R 23	30.00ef	R 17	38.50h
17	R 19	43.80h	R 13	33.30f	R 6	40.00h
18	R 17	49.40i	R 14	33.30fg	R 13	42.96i
19	R 6	50.00i	R 3	34.10gh	R 18	44.00i
20	R 10	50.10i	R 11	35.00gh.	R 12	44.60i
21	R 1	53.20i	R 6	35.70ghi	R 3	45.00i
22	R 12	50.70j	R 17	36.90hij	R 11	45.00i
23	R 13	60.00j	R 1	38.10ij	R 1	58.10j
24	R 14	63.10j	R 8	40.00j	R 4	60.00j

I.No.—Isolate numbers

D.I.—Disease indices

Values followed by the same letter (s) are not significantly different according to Duncan's Multiple Range Test ($P=0.05$).

this pathogen in soil. Further, results of Duncan's Multiple Range Test revealed that these isolates were not present in discrete groups but were overlapping with each other in pathogenic characters. All the four isolates were active in causing dry rot of tubers at moderate rate both in moist and dry chambers. It was slow in dry chamber as compared to moist chamber. No infection was observed in intact tuber indicating that the pathogen was not able to penetrate the intact surface (Table 3). Statistical analysis revealed that the four isolates had different potentialities to cause tuber rot and had overlapping pathogenic characters. Similar to the present study, Shrivastava (3) has also reported variable degree of pathogenicity of *R. solani* isolates on potato cultivars.

Table 3: Pathogenicity of different isolates of *R. solani* causing dry rot of potato in dry and moist chambers.

Dry chamber			Moist chamber		
Incubation-15 days					
S.N	I.N.	D.I.	I.N.	D.I.	
1	R 26	4.21	R 27	12.50	
2	R 27	8.31a	R 26	16.70a	
3	R 5	8.31a	R 28	16.70a	
4	R 28	12.50	R 5	25.00	
Incubation-30 days					
S.N.	I.N.	D.I.	I.N.	D.I.	
1	R 26	16.80a	R 26	20.80a	
2	R 27	20.80ab	R 27	20.80a	
3	R 28	20.80ab	R 28	25.00ab	
4	R 5	25.00b	R 5	29.20b	

I.N. - Isolate number

D.I. - Disease indices

Values followed by the same letter (s) are not significantly different according to Duncan's Multiple Range Test (P = 0.05)

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TERRACE WIDTH IN RELATION TO NATURAL SPREAD OF POTATO MOSAIC AND MARGINAL FLAVESCENCE DISEASES**

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Thresh (11) has reviewed the literature on cropping practices on the spread of virus diseases. In crops raised from healthy seed potatoes and protected by insecticides, the spread of viral and mycoplasmal diseases is brought in by migrant vectors (8). Field edges harbouring wild plants (weeds) may act as effective traps for migrant viruliferous vectors (1, 2, 4) and provide conditions suitable for the spread of these diseases. Under such conditions a disease gradient starting from the field edge to the centre of the field is likely to exist. Consequently, width of a terrace is likely to have an effect on the disease incidence. Effect of width of a terrace on the incidence of potato mosaics and marginal flavescence diseases is not known. Since these studies could yield valuable data of practical importance in disease free seed production in hills the incidence of potato mosaics (SM) and marginal flavescence (MF) diseases was studied in relation to the width of a terrace for two consecutive years in seed crop grown in Simla hills.

Disease free seed of potato variety Kufri Jyoti obtained from nucleus seed stocks was planted in narrower (<3m) and broader (>5m) terraces at an inter and intra-row spacing of 60 × 25 cm. Both type of terraces were located at an altitude of 2500 m.s.l. All standard cultural practices required to raise seed crop were followed. Plants with typical symptoms of mosaics and marginal flavescence were rogued out during three roguing at around 50, 70 and 100 days of crop growth. The incidence of SM and MF was based upon the total number of diseased plants observed and rogued out during the crop season.

Data were recorded for two consecutive years on large number of plants in narrower and broader terraces and subsequently in tuber samples collected from each type of terrace (Table 1). The disease incidence in the two type of terraces was then compared on percentage basis.

The results (Table 1) revealed that the incidence of SM and MF was much higher in narrower terraces, both as the current season infections and in its subsequent produce, as compared to that in the broader terraces. The trend was similar in data collected during both the years.

The higher SM and MF incidence in narrower terraces is possibly on account of an increased "edge effect" (a gradient of infection produced by migrant viruliferous vectors from field edge to the centre of the crop), prevalent in the narrower terraces

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Table 1: Incidence of potato mosaics (SM) and marginal flavescence (MF) in narrower and broader terraces

Potato crop in different types of terraces	Year	Total Number of plants examined	Number/Per cent plants found infected with			
			Mosaics (SM)		Marginal Flavescence (MF)	
			No.	%	No.	%
NARROWER (<3m)	1979	42000	36	0.09	104	0.25
	1980	42000	158	0.38	337	0.80
BROADER (>5m)	1979	66000	40	0.06	106	0.16
	1980	30000	75	0.25	165	0.55
Randomly selected samples from						
NARROWER	1980	3688	37	1.00	57	1.55
BROADER	1980	1605	12	0.75	11	0.69

as compared to the broader terraces. This, is because a high ratio of field perimeter/cropped area exists in narrower terraces in comparison to the broader terraces. Such edge effects in case of some other diseases have been reported with various types of vectors including aphids, nematodes, mites, mealybugs, white flies and leaf hoppers (6, 10).

The observations recorded here suggest that the current season infections of SM and MF diseases of potato can be minimized by growing seed crop in broader terraces in preference to the narrower terraces. Low spread of some viral diseases in large sized fields have been reported from some other countries as well (12). The spread of infection in such fields restricts around the infector plants only (9). Control of some other plant viruses by cultural practices (7) especially by increasing field size (5) and by eradicating weed hosts (3) have been achieved in some crops.

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EFFECT OF INORGANIC AMENDMENTS ON *FUSARIUM OXYSPORUM* AND WILT OF POTATO*

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The relationship between trace elements and disease severity has been established for *Fusarium* wilts of many crop plants, especially tomato (3, 4) and pigeon pea (7). Ganacharya and Wankar (2) have studied the effect of trace elements *in-vitro* on growth and sporulation of *F. oxysporum* (potato wilt isolate) but their *in-vivo* effect remained to be worked out. Present study investigates the suppressive effect of some trace elements and other chemicals on population build up of *F. oxysporum* and wilt phase, if any.

Sterilized soil filled in plastic buckets was infested with *F. oxysporum* grown on potato dextrose agar and treated with the chemicals as under:

Elements	Salts	Dose
Zn	Zinc sulphate	40 kg/ha
Mn	Manganese sulphate	40 kg/ha
Fe	Ferric sulphate	20 kg/ha
Cu	Copper sulphate	20 kg/ha
Bo	Boric acid	10 kg/ha
Mo	Ammonium molybdate	5 kg/ha
Na	Sodium nitrite	10 kg/ha

Each treatment was replicated five times. Treated soil was planted with tubers of cv. Kufri Chandramukhi, two tuber each. Fungus population was estimated at the time of soil treatment and subsequently at monthly interval employing dilution plate method and peptone-PCNB (modified) medium (6). Wilt studies were carried out in earthen pots using soil and fungus inoculum grown on sand-maize medium (9) in 10:1 ratio. Wilt index was calculated at 20 and 50 days crop growth following the method of Mitchell and Alexander (5).

Maximum suppression of fungal population was observed in Mo amended soil (4.9 times increase over initial population) followed by Bo (10.9 times increase) and sodium nitrate (11.0 times increase) as compared to 23 times increase in untreated control. Reduction in fungal population by Cu and Zn was marginal whereas Mn and Fe stimulated the fungal growth (Fig. 1). At 20 days of crop growth maximum reduction in wilt index was observed in sodium nitrite amended soil followed by Mo

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2 A.M.U Aligarh

3. B.F.D.C Rath (U.P)

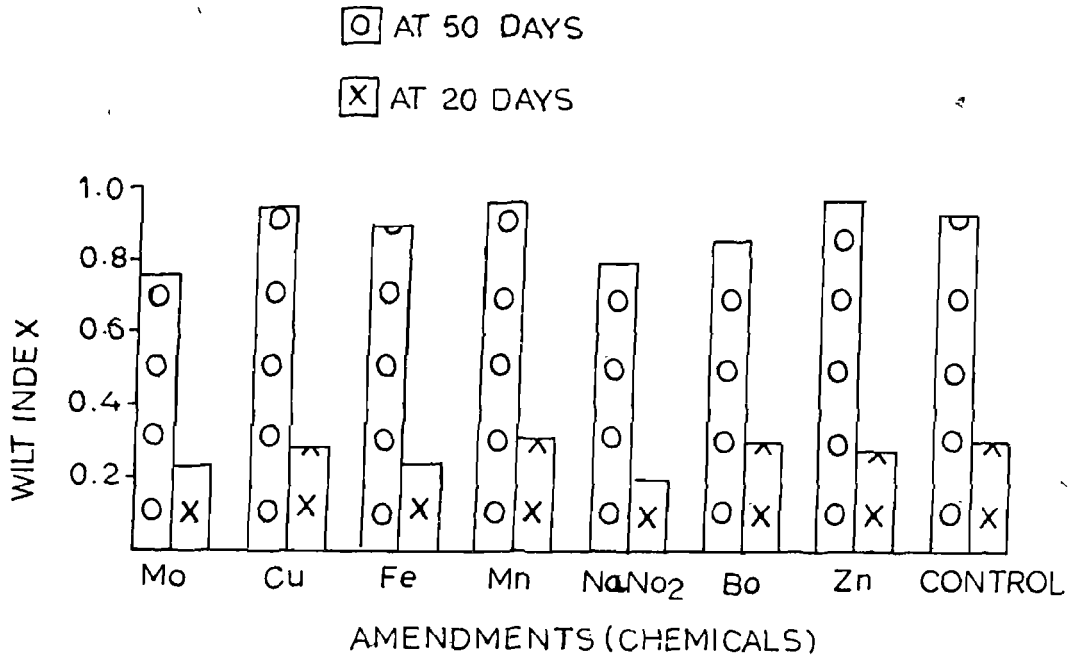


Fig. 1: Wilt index in soils amended with trace elements and sodium nitrite

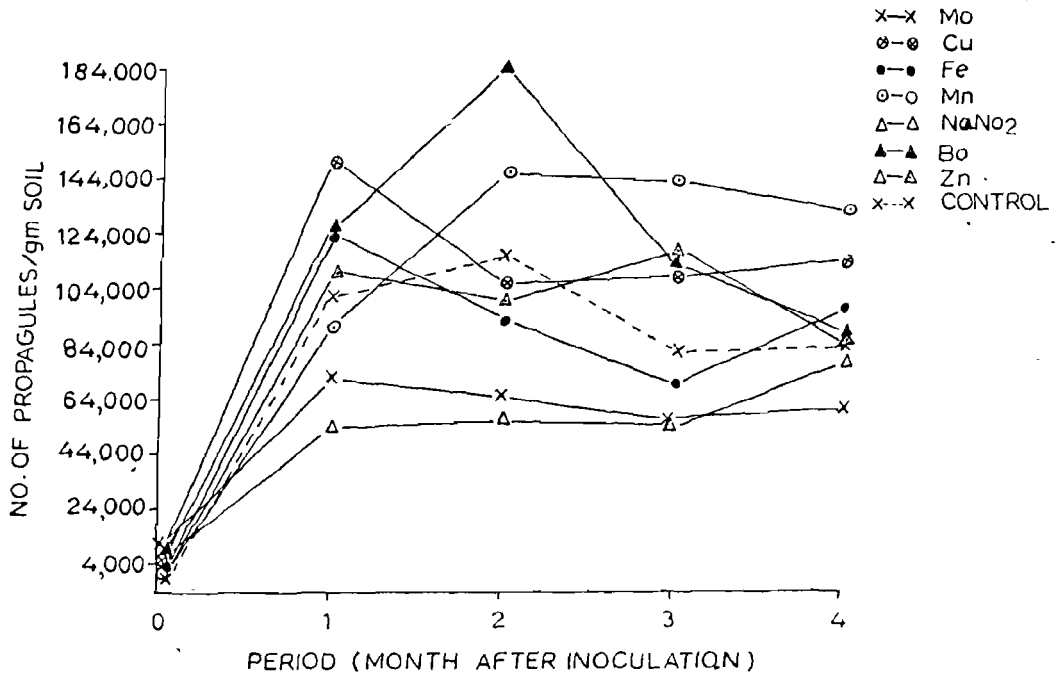


Fig. 2: Population build up of *F. oxysporum* in soil amended with different chemicals

(0.2 and 0.22 respectively). Whereas at 50 days crop growth Mo proved better over sodium nitrite (0.75 and 0.79 respectively). Other chemicals did not show marked effect on wilt index (Fig. 1)

Mo is known for its inhibitory effect against *Fusaria* through reduction in fungal growth and sporulation (2, 7). Suppression of fungal population and wilt index by soil application of Mo in the present studies is therefore in cofirmity with earlier reports (2, 7). As regards suppressive effect of sodium nitrite, both Na and NO₂ ions are harmful to plants and fungi (1, 8) and, possibly they could be harmful to *F. oxysporum* as well.

Senior author is thankful to Dr. S.K. Bhattacharyya for his valuable suggestions and guidance in preparation of this manuscript.

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EFFECT OF 2, 4, 5 — TRICHLOROPHENOXY ACETIC ACID ON THE STORABILITY OF POTATO (*SOLANUM TUBEROSUM* L.)

T.A. JOSEPH AND H.S. CHAUHAN¹

Foliar spray of 2, 4, 5 trichlorophenoxy acetic acid (2, 4, 5-T) has been reported to be effective in delaying sprouting in potatoes (1, 2, 3, 4). In Palni hills (Tamilnadu) seed potatoes after harvest in September/October are stored in ordinary *katcha* country stores till planting time in April/May. Keeping the seed potatoes in this type of stores for such long periods causes heavy losses due to shrinkage and rottage. Besides, oversprouting makes the seed potato tubers physiologically weak for raising a good crop. Therefore, if the oversprouting of the tubers can be controlled under such conditions, the tubers will retain their ability to give a good crop of potato when planted. Hence the present investigation was undertaken at the Central potato Research Station, Mannavanur, Kodaikanal (2000 metres MSL) during 1975-76.

Standing crop of Kufri Jyoti in field was sprayed 5 weeks before harvest with 100 ppm 2, 4, 5-T. and was harvested in the second week of November. The tubers were stored in a *katcha* thatched-country store as follows:

Treatments: T1 = treated tubers stored in a pit 2 ft. deep; T2 = untreated tubers stored as in T1; T3 = treated tubers stored in the floor 4 inch heap; T4 = untreated tubers stored as in T3; T5 = treated tubers stored in gunny bag; T6 = untreated tubers stored as in T5.

For each treatment 40 kg of seed tubers were kept. The maximum and minimum temperatures within the store, were measured twice at 8.00 AM and 2.00PM.

Observations on total loss in weight, weight of rotten tubers and sprout growth were recorded at weekly intervals during the storage period. One kg tuber from each treatment were desprouted and the weight of sprouts was recorded. The remaining healthy intact tubers from this experiment and fresh seed tubers (harvested in February) received from Central Potato Research Station, Jalandhar were planted in a randomised block design with 4 replications. The net plot size was 9 m² per replicate and the tubers were planted at a distance of 25 cms apart. Fertilizer at the rate of 80 kg N: 180 kg P₂O₅: 80 kg K₂O/ha was applied to the crop. All the recommended cultural practices were followed during the crop season. Per cent germination was recorded at 40 days after planting. At harvest time in September, data on total tuber yield/plot, number of tubers/plot and average tuber weight were recorded.

The physiological loss, rottage and sprout weight were less in the 2, 4, 5-T treated tubers as compared to the controls (Table 1). Physiological losses, and

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Table 1: Total losses in the seed tubers (%) and weight/length of sprout.

Treatment	Days of storage					Weight of Sprouts gms/kg of tuber at 150 days of storage (mm)	Mean sprout length
	30	60	90	120	150		
T1. Treatment tubers stored in a pit 2 ft. deep	1.13 (0.13)*	3.63 (0.0)	7.38 (0.0)	12.36 (0.38)	20.5 (0.5)	0.15	0.8
T2. Untreated tubers stored as in T1	2.25 (0.25)	5.00 (0.63)	10.00 (0.0)	15.00 (0.63)	30.75 (2.75)	0.40	1.5
T3 Treated tubers stored in the floor 4 inch heap	2.05 (0.0)	5.00 (0.0)	11.25 (0.0)	16.25 (0.0)	25.0 (1.00)	0.12	0.8
T4. Untreated tubers stored as in T3	3.75 (0.5)	6.25 (0.0)	11.25 (0.0)	17.5 (0.0)	29.75 (4.63)	0.35	1.8
T5. Treated tubers stored in gunny bag	5.00 (0.13)	7.5 (0.25)	12.5 (0.0)	17.5 (0.0)	27.5 (1.0)	0.20	1.5
T6. Untreated tubers stored as in T5	2.5 (0.25)	7.5 (0.25)	10.0 (0.0)	17.5 (0.0)	31.25 (5.5)	0.55	3.2

*Per cent loss due to rottage on weight loss is given in the parenthesis.

rottage were minimum in the treatment where the tubers were stored in the Pit (T1) followed by storage on the Floor (T3). The mean maximum and minimum monthly temperatures in the store are given in Table-2.

The final plant stand in the different treatments shown that 2, 4, 5-T treated seed tubers even after 150 days of storage gave higher germination than the controls. This may be attributed to the better physiological condition of the treated seed tubers. However, the final plant stand of the fresh Jalandhar seed was the best (Table-3).

The 2, 4, 5-T treated seed tubers also showed a higher yield performance than the controls. The seed stored on the floor (T3) was found to yield significantly more than the control (T4). The yield performance of the February harvested fresh seed was superior to that of the other treatments. However the yield of fresh Jalandhar seed was not significantly different from that of the 2, 4, 5-T treated seed but significantly higher than that of the controls. The tuber number/plot and the average tuber weight were not statistically significant (Table 3).

It can be seen that foliar spray of 2, 4, 5-T is effective in reducing physiological losses and rottage, and the seed value of the tubers was not affected by 2, 4, 5-T application. It is in agreement with the findings of Singh et. al. (3). Therefore, foliar spray of 2, 4, 5-T can be effectively used in long term storage of seed tubers in *katcha* country stores where cold store facilities are not available. However, 2, 4, 5-T can not be used in ware crop because of the presence of highly toxic manufacturing impurity, dioxin (4). Hence, foliar spray of 2, 4, 5-T can be used only in seed crop, where the produce is used for seed purpose, and thereby the storage losses can be minimized.

Table 2: Mean monthly temperature in the shed

Month	Maximum °C	Minimum °C
December	19.0	8.5
January	19.2	6.3
February	21.7	5.9
March	23.8	8.0
April	24.2	8.8

Table 3: Final plant stand, mean tuber yield, tuber number and tuber weight

Treatments*	Final plant stand** (%)	Mean yield kg/plot***	Mean tuber number/plot	Average tuber weight gms.
T ₁	68.0 (68.3)	6.54	252.00	27.0
T ₂	56.0 (56.0)	5.07	199.50	25.3
T ₃	71.5 (71.7)	7.62	247.50	30.7
T ₄	40.0 (40.0)	3.56	135.00	26.9
T ₅	72.0 (72.5)	7.27	246.25	29.3
T ₆	46.0 (45.9)	4.60	176.75	26.2
T ₇ Fresh Jalandhar seed	79.5 (87.7)	9.11	292.00	33.0
C.D. (0.05)	10.9	3.28	115	6.81

* Details of treatments are given in Table 1.

** Values in parenthesis are transformed values.

*** Net plot = 9m².

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Abstracts of papers presented at 8th Annual Meeting of IPA

ADAPTABILITY OF *PHYTOPHTHORA INFESTANS* TO FUNGICIDES — B.P. SINGH, S.K. CHAKRABORTY, S. ROY AND S.K. BHATTACHARYYA — Central Potato Research Institute, Simla-171 001

Adaptability in *Phytophthora infestans* against four fungicidal formulations viz. Ridomil ZM 280 FW (metalaxyl 4%+Ziram 24%), SAN 518F (oxadixyl 8%+mancozeb 56%), SAN 506F (oxadixyl 10%+copper 40%) and Dithane M-45 (mancozeb) was evaluated by i) passing the fungus through increasing doses of fungicides and ii) successive inoculations at a fixed site for six consecutive days. Fungus showed least adaptability to mancozeb where it did not grow beyond 0.001%. Next in increasing order was SAN 506F which supported the fungus growth upto 0.01% but not at 0.1% or above. Adaptability to Ridomil and SAN 518F was comparatively higher, maximum being to that of Ridomil. In both these fungicides fungus could grow upto 0.1% fungicidal concentration beyond which (0.5%) it did not develop despite repeated inoculations. It is concluded that chances of development of resistant strains of *P. infestans* against oxadixyl formulations are low as compared to metalaxyl but not remote as suggested by Gisi *et al.*, (1983).

WART DISEASE OF POTATO IN DARJEELING HILLS — PRESENT STATUS
— Presented by P.H. SINGH on behalf of CPRI, Directorate of Plant Protection, Govt. of India and Directorate of Agriculture, Govt. of West Bengal.

The survey conducted in 1985 covered the Bijanbari, Sukhiapokhri, Takdah and Kurseong Development Blocks during summer and Bijanbari, Sukhiapokhri, Takdah, Kalimpong I and II Development Blocks during winter crops where wart was recorded in earlier surveys. Out of the total potato areas (4390 ha. approx.) in the district, 633.4 ha was found to be under immune varieties (Kufri Jyoti/Pimpernel) during this survey. Out of the total 68 localities surveyed during summer crops, wart was found in 12 localities. During winter crops 71 localities were surveyed but no wart could be observed in any locality. 474 composite soil samples were collected in both summer and winter crop survey to observe the presence of resting spores by dry-sieving technique and in 134 samples spores were present either less than 200 or more than 200 spores/gm. of soil. It is apparent that even though wart is not observed in many localities on the tubers due to shift to immune cultivars, the spores are present in the soil and can infect the susceptible cultivars, if planted.

OCCURRENCE OF POTATO AUCUBA MOSAIC DISEASE IN BALLIA AND BIHAR SHARIF AREAS — R.A SINGH AND V.V CHENULU — Central Potato Research Institute, Shimla-171-001, H.P. Indian Agricultural Research Institute, New Delhi-110 021

Potato is cultivated intensively in Ballia (eastern Uttar Pradesh) and Bihar-Sharif (Bihar) areas. Few years ago these areas were surveyed for recording the occurrence of aucuba mosaic disease of potato. The disease was observed in varying intensity ranging from 0 to 12 per cent in Ballia and 0 to 9% in Bihar Sharif in old potato cultivars viz. Kufri Chandramukhi and Kufri Sindhuri. More prominent symptoms were observed in cooler and humid weather during late December and early January. The disease was found to be caused by G strain of potato aucuba mosaic virus (PAMV) which induces mainly aucuba symptoms (bright yellow spots) and not foliar and tuber necrosis. The reason of less incidence of the disease even in the old potato cultivars was probably the non-transmissibility of PAMV G strain by Aphid *Myzus persicae* even in the presence of helper virus Y. However, the disease was found to spread upto 20% by cutting knife. Hence aucuba mosaic disease of potato prevalent in Ballia and Bihar Sharif areas could be easily managed by using healthy seeds of new cultivars and avoiding use of cut tubers as seed.

EFFICIENCY OF SELECTION IN EARLY GENERATION OF POTATO BREEDING PROGRAMMES — T.R. DAYAL — Central Potato Research Station, PO Sahaynagar, Patna, Bihar.

A study was carried out at Central Potato Research Station, Sahaynagar, Patna by evaluating genotypes of six cross combinations in F_1 seedling and F_1C_1 clonal generations and testing their performance relationship for yield. The study revealed both positive and negative correlation between the performance of the two generations. The study has indicated that the selection in F_1 seedlings is not reliable. To overcome such biasness of early generation selection three methods: (i) positive selection or Elite selection (ii) negative selection and (iii) bulk selection or family selection are suggested to be operated simultaneously in F_1 seedling generation of potato. This scheme would be more economical and efficient as thousands of genotypes could be properly taken forward in a single bag and evaluated critically in late clonal generations for their selection as suitable cultivar.

BREEDING IMPROVED POTATO CULTIVARS FOR NORTH-EASTERN INDIAN PLAINS — T.R. DAYAL AND C.L KHUSHU — Central Potato Research Station, Sahranagar, Patna

The main emphasis for breeding varieties for North-eastern plains has been on early maturing varieties which may:

- i. complete their life cycle within 70-90 days.
- ii. have some tolerance to higher temperature during planting and harvesting time.

- iii. yield at least 10–15% higher than the standard controls like Kufri Chandramukhi and Kufri Jyoti.
- iv. may fit into potato-onion-paddy cropping system of the area

To achieve these objectives first the old existing stocks of about 315 hybrids of different cross bred populations have been properly screened for maturity and yield and secondly since 1984 about 25–35 new clones have been developed from 1, 17, 560 hybrid seeds of 67 crosses. Through this rigorous process of selection, trial and evaluation following hybrids have been found promising with respect to their maturity and yield at different locations in Regional Adaptability trials conducted in Bihar and West Bengal plains. These hybrids have shown 15 to 45% higher yield than the standard controls Kufri Chandramukhi and Kufri Jyoti. Selected hybrids are:

- A. JN-1501, PJ-376 : Early maturing in 70 days
- B. JN189 — : Medium maturing main crop cultivar for 90 days.

The other promising hybrids in the second line of selection and testing are: T1/5, CRD/10–12, 31/33, 77/1, 77/2, PS/N-124, 142, PS/M 18, 23, 43, 75, 97, 98, 115, PS/I-1771, U-373, V-282, V-327

POPULATION DYNAMICS OF APHID IN POTATO CROP AT PATNA — GULAB RAM — Central Potato Research Station, Patna, Bihar.

A study was conducted on population dynamics of aphids in potato crop during 1972–73 to 1984–85. Four species of aphids viz; *Myzus persicae* Sulz., *Aphis gossypii* Glov., *Aphis fabae* Scop., and *Rhopalosiphum rufiabdominalis* Sasaki were commonly found in potato crop at Patna. *M. persicae* is the principal vector of viral diseases viz., PLRV and PVY in potato crop. It appears during last week of December to 2nd week of January and crosses the critical level (20 aphids/100 leaves) during 2nd or 3rd week of January. Peak period for both *M. persicae* and *A. gossypii* was recorded during 2nd and 3rd week of March. *M. persicae* dominates over other species on plant foliage. The population of *A. gossypii* and *A. fabae* is also found high in the beginning of the season but it declines from January onwards. The root aphid (*R. rufiabdominalis*) first appears on plant foliage in the 2nd week of November and there after migrates to the root zone where it multiplies enormously and causes severe damage.

POTATO PRODUCTION FROM TPS TUBERLETS IN HOOGLY DISTRICT OF WEST BENGAL — M.D. UPADHYA, M.S. KADIAN AND K.C. THAKUR — International Potato Center, Region VI, (South Asia) IARI Campus, New Delhi-12

Percentage survival and average tuber yield/m² (kg) of all TPS progenies was recorded almost similar to the standard local cultivar Kufri Jyoti. Hybrid HPS-II/3 produced the maximum number of extra large size tubers and was also the highest yielder. Tubers of HPS-II/3 and HPS-7/30 were most uniform in shape, size and colour.

CONSTRAINTS OF POTATO PRODUCTION IN WEST BENGAL — PEST FACTOR — MD. MOHASIN, P.K. PAL, A.K. SOMCHOUHURY AND P.C. SENGUPTA — Bidhan Chandra Krishi Viswavidyalaya Kalyani, Nadia, West Bengal-741 235

A bird's eye view on the pest profile of potato in West Bengal reveals that out of seven insect pests occurring regularly on the crop, three viz. aphids, cutworm and epilachna beetle appear to be of economic significance. The pests were asymmetrically distributed in the three potato growing belts in West Bengal. The aphid population often crosses the critical level during the early-mid season of the crop period. Similarly, one or the other pest remains very much active on the crop throughout its growth period. Studies pertaining to the damage potential and the seasonal abundance of these pests envisage optimum time for undertaking control measures against them. Timely application of pesticides resulted significant increase in yield over the control plots.

BACTERIAL WILTING PROBLEM OF POTATOES IN WEST BENGAL — D.C. KHATUA AND N. MUKHERJEE — Department of Plant Pathology, BCKV, Kalyani

The distribution pattern of bacterial wilt is often different in potatoes compared to other crops like brinjal, tomato, chilli or tobacco. Unlike others potatoes show significant incidence even in heavy clay soil area. Usually alluvial, red-lateritic and terai soil area including both high and low rainfall areas and acidic to neutral pH soils show incidence commonly in the area of 2–15% with some peaks reaching 50–60% even in some years. For other crops however the incidence percentages are still non-uniform in different area. Contribution of other crop and weed hosts is very important. Crop hosts recorded include brinjal, chilli, tobacco, jute, and banana in this area. Weeds so far listed include *Croton sparsiflorus*, *Physalis minima*, *Solanum xanthocarpum*, *Xanthium chinensis*, *Canna indica*, *Datura stramonium* and *Cestrum diurnum*. Very often weeds show slow wilting or stunting symptoms which indicated that they may act as reservoir for a longer period. The incidence of the disease on a crop grown on a fallow land also indicated the possible source as weeds. The disease is characteristically present on host crops in most of the common rotations including those with cereals. The depth of the problem thus appeared to be quite complicated.

BLACK SCURF — A SERIOUS DISEASE OF POTATO IN THE PLAINS OF BIHAR — DEVENDRA SAHAI — Central Potato Research Station, Patna-801 506

Black scurf (*Rhizoctonia solani* Kuehn) of potato is known to be wide spread in India, but no comparable reports exist of the incidence and losses caused under different conditions. Extensive surveys in Bihar showed the disease on 16 cultivars. Of 139 holdings examined disease incidence on tuber was over 50 percent in 3.2 per cent stocks grown on sandy loam soil, and in 73.3 per cent and 44.2 per cent stocks grown respectively on loams and clayey loams. Also the disease was more when maize, paddy, *Crotalaria juncea* L. and *Sesbania* sp. crops preceded potatoes

than on fallow lands. Yield from experimental seed lots with 20 per cent to 100 per cent disease incidence was found to be about 18 per cent less. Evidence is also presented that planting infected seed led to almost 100 per cent disease incidence on the progeny.

CHEMICAL CONTROL OF CHARCOAL ROT OF POTATO IN EASTERN PLAINS OF INDIA — DEVENDRA SAHAI — Central Potato Research Station, Patna-801 506

Benlate (benomyl), Bavistin (carbendazim), Difolatan (captafol), Captan (captan), Agallol-3 (methoxy-ethyl mercuric chloride), Thiram (tetramethyl thiuram disulphite), thiourea, sodium benzoate and potassium meta-bisulphite completely inhibited the growth of the potato isolate of *M. phaseolina in-vitro*. These chemicals were also found effective in checking the development of charcoal-rot on cut and whole tubers of potato cultivar Kufri Chandramukhi. Chemicals were effective as pre-inoculation treatments only. Pre-storage treatment of potatoes with methoxy-ethyl mercuric chloride (0.4%), captan (0.2%), provided the best control of the disease. Tri-phenyl tin-hydroxide (0.2%), tetramethyl thiuram disulphite (0.2%) and captafol (0.4%), benomyl (0.2%) and carbendazim (0.2%) were also found effective. In a separate study conducted during 1981, non-toxic chemicals namely, thiourea (1%), boric acid (4%), sodium benzoate (0.4%) and potassium metabisulphite (0.4%) also provided protection to the treated tubers over a period of three months.

VIRUS AND MYCOPLASMA DISEASE PROFILES IN COMMERCIAL POTATO CULTIVARS AND THEIR SUITABILITY IN DISEASE FREE SEED PRODUCTION PROGRAMME — SARJEET SINGH AND V.K. GARG — Central Potato Research Station, Kufri

Virus (PVX/S/PVA/PVY/mosaics) and mycoplasma (MF & PTR) disease profiles in nine commercial potato varieties were studied at CPRS, Kufri by using pre and post-harvest detection techniques for determining their suitability for production of disease free seed potatoes. The varieties were categorised in different groups by using 0-16 per cent incidence scale for individual and combined diseases. In individual disease component tests cultivars Kufri Jyoti, K. Badshah, K. Sherpa, K. Muthu and K. Chandramukhi were found to have minimum (2.1-4.0) PVX/S profiles followed by K. Sindhuri, Uptodate (4.1-8.0) and K. Badshah and K. Lalima (10.1-14.0). The PVA/PVY/mosaics profiles were minimum (0-2.0) in vars. K. Jyoti, K. Badshah, K. Lalima, K. Bahar, K. Chandramukhi, and K. Muthu. K. Sindhuri had slightly higher profiles (2.1-4.0) for these diseases while K. Sherpa and Uptodate had the highest disease incidence index (4.1-6.0). The MF and PTR disease profiles were least (0-2.0) in varieties K. Badshah, K. Bahar, K. Lalima, K. Sherpa and K. Sindhuri while K. Jyoti, K. Muthu, and Uptodate ranged between 2.1 to 4.0 disease index, and K. Chandramukhi and K. Muthu had the highest disease index of 8.1-10.0. In combined disease profiles of four types of diseases K. Badshah was the

best with disease index 4.8 followed by K. Jyoti with 6.9 and K. Sindhuri with 0–9.6 indices. All other varieties had the disease index 13 to 16. These findings suggest that varieties, K. Jyoti, K. Badshah and K. Sindhuri were found to have slow rate of degeneration and were easy to maintain in disease free condition while other varieties had a higher rate of degeneration and required concerted efforts to maintain them in disease-free condition.

IMPROVED TECHNIQUE TO MAXIMUM POTATO PRODUCTION IN THE EASTERN PLAINS OF INDIA — V.S. KUSHWAH. — Central Potato Research Station, PO: Sahay Nagar, Patna-801 506, Bihar

The average yield of potato in the eastern plains of India is considerably low as compared to northern and western plains. The mean potato yield of Gujarat is the highest (32.9 t/ha) among all the potato growing states in India which is mainly attributed to specific practices adopted under river bed cultivation in Deesa. Keeping in view the methodology being followed in river bed cultivation in Gujarat, yield maximisation trial was conducted with Kufri Sindhuri using cut tubers for the two consecutive years (1985–86 & 1986–87) at the Central Potato Research Station, Patna. On an average, tuber yield of 47.8 t/ha was achieved at a plant population of 2,50,000 plants/ha, inter and intra row spacing at 40cm x 10cm, FYM application @ 5–15 t/ha and fertilizer doses @ 400 kg N, 80 kg P₂O₅ and 160 kg K₂O/ha. The study revealed that high stem density (53–57 stems/m²) may result in spectacular increase in potato yields.

AN AGRO-ECONOMIC APPRAISAL OF THE OPERATIONAL RESEARCH PROJECT ON POTATO IN BIHAR — P.S. DAHIYA, H.C. SHARMA, JANARDANJEE, V.S. KUSHWAH, B. PRASAD, R.P. RAI, GULAB RAM. Central Potato Research Institute, Shimla, and Central Potato Research Station, Patna.

The operational Research Project (ORP) on potato in Bihar was initiated in Danapur A&B clusters (Patna district) and in Noorsarai cluster (Nalanda district) during 1974–77 with a view to stepping up seed potato production. The ORP programmes were terminated after 1982–83 in Danapur A&B and after 1984–85 in Noorsarai. During 1985, a survey was conducted to assess the impact of ORP and the results are presented briefly. The sample farmers allocated 1.14, 0.27 and 0.55 ha to potato in Danapur A, B and Noorsarai clusters and obtained yields of 256, 250 and 181 q/ha, being two-times the yield level of Patna district and 1.3-times that of Nalanda district respectively. Farmers applied 157, 83, 77; 146, 41, 59; and 131, 61, 82 kg/ha of N, P₂O₅ and K₂O in these clusters. FYM was not applied in Danapur A while in the other two clusters it was applied @ 23 and 63 q/ha. Eighty six percent farmers weeded their crop while 90 percent of them adopted plant protection measures. Fifty percent rogued seed potato crop in Danapur A and Noorsarai and 80% in Danapur B. Ninety percent farmers in Danapur A, 45 and 35% in Danapur B and Noorsarai cut the haulms while earthing up was carried out by almost all 1 to 2

times. Grading was done by 94, 86 and 75% farmers in the respective clusters. Forty, twenty-five and thirty-two per cent farmers obtained seed from government agencies while 32, 64 and 41% used home-grown seed. About 69, 95 and 82% area was covered under high yielding varieties. The gross return per rupee invested on potato cultivation was found to be Rs. 1.63, 1.59 and 1.09 in these clusters.

POTATO PRODUCTION IN NON-TRADITIONAL AREA — P.K. MISRA AND J.K. DHAL. Orissa Agric. University

A system for production of disease free seeds has been established, with the standard varieties Kufri Chandramukhi, K. Jyoti, K. Badshah, K. Sindhuri and K. Lalima. Planting single rows spaced 50/60 cm apart with 120:80:100 kgs of N:P₂O₅:K₂O respectively per hectare with an irrigation interval of 7 days for hot and dry regions, gave optimum yield. Common diseases were late and early blight, bacterial wilt (brown rot). Though cut worms, epilachna beetle, thrips, aphid and tuber moth are the common pests, soil application of thimet 10-G controlled soil and sucking pest of potato crop upto a period of 60 days after which the red ants/white ant creates problem in attacking the tubers and subsequently by brown rot. True potato seeds (TPS) a new technique found successful in potato cultivation in Orissa gave yield of 98 to 173 q/ha, at all research centre.

TBZ + 8 HYDROXYQUINOLINE, AN EFFECTIVE FUNGICIDE FOR CONTROL OF BLACK SCURF OF POTATO — R.P. RAI. Central Potato Research Station, Patna-801 506

The viability of medium size (2–3mm) and large size (3–7mm thick) sclerotia from the black-scurf affected tubers earlier treated with 0.50% Emisan-6 (OMC) and 1.0% Acetic acid + 0.05% Zn SO₄ (recommended concs. for both the chemicals, respectively), and 0.50, 0.75 and 1.0% concs. of TBZ + 8 Hydroxyquinoline was assessed on PDA at 25°C. The phytotoxicity of all the three chemicals at respective concentrations was also studied by dipping well sprouted tubers in the solutions for 30, 15 (recommended durations for OMC and acetic acid + Zn SO₄) and 30 minutes, respectively.

The efficacy of TBZ + 8 Hydroxyquinoline at 1.0% conc. in killing all (100%) large size sclerotia, and its phytotoxic effects on sprouts was similar to that of other two chemicals. This new fungicide is as useful as the other two for treating unsprouted tubers affected with black-scurf with additional advantage of being safe and readymade formulation, and hence a preferred substitute.

MORPHOLOGICAL PARAMETERS INFLUENCING POTATO YIELD IN EASTERN PLAINS OF INDIA — LALLAN SINGH. Central Potato Research Station, Patna-801 506, Bihar.

Correlation studies between morphological characters and tuber yield were carried out at Central Potato Research Station, Patna, Bihar. The results based on 20 genotypes revealed that plant height, stem girth, number of nodes, chlorophyll content of the leaf, leaf area duration (LAD), and dry weight of the above ground parts (haulms) were positively correlated with tuber yield. Internodal length, leaf size and leaf angle, however, showed no association. Total biological yield (biomass) was observed to be very closely related ($r=0.9$) with yield (biomass) but its partitioning towards tuber i.e. harvest index had no or rather negative correlation ($r=-0.35$ to -0.52) in the present study. Correlation coefficients of tuber yield with leaf number and leaf area index (LAI) were on increase during their declining phase (75 days after planting onward) and thus exhibited the significance of longevity of the leaves. Further studies carried out with segregating population of five crosses during 1985-86 and 1986-87 also confirmed most of these findings. It is, thus, concluded that a genotype possessing tall and stout stem bearing more chlorophyll containing leaves of longer longevity with capacity to synthesize more biomass may be a desirable plant type for higher yields under short day conditions of eastern plains of India.

PREVALENCE OF FUNGAL FOLIAR DISEASES OF POTATOES IN BIHAR — BHAWANI PRASAD. Central Potato Research Station, Patna-801 506

During two crop season (1985-87), field surveys were conducted at different locations in Patna, Ranchi, Nalanda and Bhojpur districts with a view to having recent informations on the prevalence of fungal foliar diseases viz. late blight (*Phytophthora infestans*), early blight (*Alternaria solani*) and *Phoma* leaf spots (*Phoma* sp.). Among these diseases, late blight was prevalent at several locations and its intensity (% foliage area damaged) in fungicide-sprayed and unsprayed crop varied between 1 to 25% and >25 to 90%, respectively. However, at certain locations in Ranchi where crop was younger due to delay in planting, its intensity in unsprayed crop was <25%. Among the remaining two diseases, early blight was prevalent in Ranchi area with 1-50% intensity while *Phoma* leaf spots were prevalent at few locations in Patna and Nalanda with 10-70% intensity on cv. Kufri Jyoti. The causal organism of *Phoma* leaf spots was identified as *Phoma sorghina* while *Epicoccum nigrum* and *Alternaria alternata* were associated with the disease as weak pathogens. The results show that late blight has gained increasing importance and resistant cvs. Kufri Jyoti and Kufri Badshah are also affected.

OPERATIONAL RESEARCH PROJECT IN NALANDA AND BHOJPUR (BIHAR) AND ITS IMPACT ON POTATO PRODUCTION — JANARDANJEE, BHAWANI PRASAD AND V.S. KUSHAWAH. Central Potato Research Station, Patna-801 506

In Nalanda district which is an important potato growing region in Bihar, an Operational Research Project (ORP) was initiated during 1975–76 with the main objective of stepping up potato production through transfer of improved technology including introduction of improved cultural practices, disease resistant and high yielding varieties, seed plot technique of producing disease free seed and control measures to prevent pests and disease. On the basis of bench-mark-survey, 4 clusters of villages viz. Charuipar, Pariauna, Jamunapur and Doyia under Noorsarai block were adopted. Consequently, the potato yields of the project area had gone up from 165 q/ha in 1975–76 to 300 q/ha in 1983–84 as well as 80% of the total cropped area of potatoes had become saturated with improved varieties by the end of 1983. A random survey of the cost of potato production and returns from the produce carried during 1984 also showed better impact of ORP since the net profit per unit area in Doyia, Charuipar, Pariauna and Jamunapur was estimated to be Rs.12.8, 14.2, 14.7, and 14.6 thousands/ha respectively. During 1985, the project was initiated at a new site viz. Koelwar with 2 villages. Bhadwar and Kulharia in Bhojpur district where the project is still under operation. In these villages also an increase in yield around 50% was recorded in improved varieties in comparison to traditional varieties/cultivation practices.

APHID BUILT UP IN POTATO IN EASTERN U.P. — S.M.A. RIZVI AND H.M. SINGH. N.D. University of Agriculture and Technology, Faizabad.

Regular weekly surveys were conducted in potato crop at Faizabad and nearby areas during the crop years 1982–83 to 1986–87 to determine the low aphid period of the crop. Two aphid species viz. *Aphis gossypii* Glov. and *Myzus persicae* Sulz. were noticed during these surveys. The data collected during the course of investigation indicate that *A. gossypii* appears earlier i.e. between third and fourth week of November and reaches critical level (20 aphids/100 compound leaves) by the end of December. *M. persicae*, the principal vector of potato viruses appears late i.e. during the last week of December and generally reaches critical level in the third week of January suggesting delayed haulm cutting in seed crop.

The data thus obtained has great significance for seed potato growers of eastern U.P. as they can cut the haulm in the third week of January instead of first week of January which was generally recommended earlier by the Seed Certification Agency. This 10–15 days delay in haulm cutting increases the yield significantly encouraging more farmers to take up seed production in this part of country.

BULKING HABITS AND BULKING RATES EXHIBITED BY SOME VARIETIES OF POTATO IN THE GANGETIC PLAINS OF WEST BENGAL — N.L. CHAKRABORTY. West Bengal Comprehensive Area Development Corporation, Calcutta.

The Bulking habits and Bulking rates of five potato varieties, namely, Kufri Jyoti, K. Badshah, K. Bahar, K. Sindhuri and K. Chandramukhi were tested at WBCADC Project, Bainchi under Pandua Block of Hooghly District in West Bengal during Rabi 1986. The results show that the bulk yield of K. Jyoti, K. Badshah and K. Chandramukhi were 109.7, 117.0 and 95.0 qtls. per acre, respectively within 60 days after sowing (DAS) representing 90, 94 and 91 per cent of the total bulk yield. K. Jyoti and K. Badshah completed 99% of bulking at 74 DAS whereas that for K. Bahar, K. Sindhuri and K. Chandramukhi was accomplished at 81 DAS. The bulk yields of K. Bahar and K. Sindhuri at 60 DAS were 98.3 and 96.0 qtls. per acre representing 82 and 81 P.C. of total bulk yield. However, these two varieties also completed 99% of bulking by 81 DAS. During 61-67 DAS K. Sindhuri exhibited the highest rate of bulking (185.71 Kg/day/acre), followed by K. Bahar (133.28) and K. Jyoti (109.42). During 68-74 DAS the highest bulking rate was exhibited by K. Bahar (142.85 Kg/Day/acre), followed by K. Sindhuri (104.71), K. Chandramukhi (57.14), K. Jyoti (42.85) and K. Badshah (36.86). Considering the total bulk yields exhibited by the varieties, it is concluded that K. Badshah and K. Chandramukhi are very quick in their bulking habits and is followed by K. Jyoti. For these varieties haulm-cutting can be done during 75-81 DAS without significant reduction in yield.

RESPONSES OF POTATO TO FERTILIZATION IN NORTH-EASTERN HILL STATES — U.C. SHARMA. Central Potato Research Station, Shillong-793 009

Various experiments conducted on acidic soils in North-Eastern Hill Region, have shown that potato exhibited differential response to various fertilizer nutrients applied. Since the soils of the region are, in general, acidic in reaction and contains high exchangeable aluminium, the phosphorus has been found to be the most limiting nutrient because of its fixation in the soil immediately after its application. The response to nitrogen application is high in light textured soils of Tripura and some other areas which have less organic matter content whereas 'medium' response to this element has been reported from other states which have sub-temperate type of climate and having medium to high organic matter content of the soil. The response of potato to potassium application is less in this region. The experiments conducted recently in this region have shown that with the application of high doses of phosphatic fertilizers to potato, in some areas, the availability of native zinc has reduced due to well known Zn-P antagonism and the response to applied zinc has been reported. Magnesium has been found to increase the efficiency of urea and hence increase the yield of potato. The responses to other macro and micronutrients have been reported to be nominal and localized.

RESPONSE OF POTATO TO N, P AND K IN ACIDIC HILL SOIL OF MEGHALAYA — U.C. SHARMA AND KAMLA SINGH. Central Potato Research Station, Shillong 793 009

Field experiments were conducted during main season (March-July) of 1984 and 1985 on sandy loam acidic soil of Meghalaya to study the response of potato var. *Kufri Jyoti* to N, P and K fertilization. N was applied at the rates of 0, 60, 120 and 180 kg/ha; P at the rates of 0, 26.2, 52.5 and 78.5 kg/ha and K at the rates of 0, 50, 100 and 150 kg/ha. The response to N, P and K was found up to application of 120 kg N, 78.5 kg P and 50 K/ha, respectively. The increase in tuber yield of potato was mainly associated with increase in the number of compound leaves and tubers/m² as a result of application of these nutrients.

ECONOMICS OF RAISING POTATO CROP FROM TUBERS, TUBERLETS AND TPS SEEDLINGS — A.N. SINGH. Central Potato Research Station, Patna

Three methods of potato crop production viz. the crop raised from tubers, tuberlets and TPS seedlings were evaluated at CPRS, Patna during the crop season 1986-87. The cost of cultivation, cost of production and net return were calculated using various parameters. The cost of cultivation from tubers, TPS-seedlings and tuberlets were Rs. 24,052.00, Rs. 21,202.00 and Rs. 20,742.00 and the production was 330, 325 and 399 qt/ha, respectively. When the produce was disposed off as ware potato, the net return from tuberlet crop was Rs. 35,388.00 as compared to Rs. 22,148.00 and Rs. 12,923.00 from tuber and TPS-seedlings crop respectively. The return from seedling crop when sold as seed tuber was calculated to be Rs. 76,298/hectare.

The results indicated that the return was high when the ware potato crop was raised using tuberlets. TPS seedlings crop could be profitably utilized for tuberlet production for raising a ware crop during next year.

*Book Review***The potato in the Human Diet.***Jennifer A. Woolfe.**Cambridge University Press, Cambridge, UK,
1987, pages XV+231, Price £17.50.*

A number of books have been published on various aspects of the potato. Some of them, like *The potato* by W G Burton, and *potato processing* by W F Talburt and Ora Smith (Eds) have chapters dealing with the nutritional value of the potato, but so far no book dealt exclusively with the role of the potato in the human diet. This gap has been filled by the book under review.

The book consists of six chapters besides an introduction. Chapter 1 deals with the structure and composition of the tuber. While chapter 2 deals with the nutritive value of some components of the tuber; the nutritive value of the nitrogenous compounds in the tuber forms a part of chapter 3. The effects of storage, cooking and processing on the nutritive value of potatoes are covered in chapter 4. Anti-nutritional factors like glycoalkaloids & proteinase inhibitors, are discussed in chapter 5 and the pattern of potato consumption in some countries of the tropics are dealt with the chapter 6.

According to the author, the book is an outcome of a felt "need for an update review, particularly in respect of developing countries" for information on consumption and nutritional aspects. However, the author has relied very heavily on the publications from developed countries. This could be due to relatively fewer publications from developing countries, but even the published material has been largely ignored as would be clear from some examples pertaining to the research work done in many institutions in India. Publications pertaining to the relationship between specific gravity and drymatter and its components (Potato Res 14: 94-95, 1971; Potato Res 18: 125-127, 1975) could have been cited on pages 9 and 23; on mineral content of potato (Indian Potato J. 4: 76-83, 1962) on page 47, and on the effects of storage on vitamin C content (J Indian Soc Refrig Engrs 3: 31-39, 1952; CRC Crit Rev Food Sci Nutr 19: 327-380) on pages 93-96. Similarly, some information on consumption of potatoes in India available in one of the publications brought out by the International Potato Centre, Lima, Peru (Social Sciences Deptt Working Paper Series No. 1980-2) could have been cited in chapter 6.

There are some editorial and proof reading errors eg. Gursky (1969) is cited on page 184 but is not cited on pages 186-196; and Nair, Behra and Ramaswamy on page 188 is printed as Nair, Rehra and Ramaswamy. However, all this does not diminish the value of the book, but it is a rather costly book at £ 17.50 (Approx. Rs. 400.00) a copy for people in developing countries. Perhaps a paper back edition may find more buyers.

Sd/-

SC Verma

Senior Scientist

Division of Plant Physiology and Biochemistry
Central Potato Research Institute
Shimla - 171001 INDIA

**Receipt and Payments Account of
Indian Potato Association, CPRI, Shimla
for the year 1986-87
(1.4.1986 to 31.3.1987)**

Items	Receipt		Payments	
	Amount Rs.	Items	Amount Rs.	
Opening Balance		Printing of JIPA	17,579.71	
1) Cash in Hand	—	Postage Charges	2,400.00	
2) Cash in Bank	59,358.02	Stationery Charges	6,028.88	
3) Cash in F.D.R.	2,53,800.00	Salaries	5,600.00	
		Audit fee	200.00	
Current receipts		Misc. Charges (Telephone)	60.00	
Annual membership fees	585.00	Refereshment for IPA	11,243.19	
Life memebership fees	5,355.00	meetings		
JIPA Sub. fees	4,008.30	Total:	43,243.19	
Reprints Charges	190.00	Cash in Hand	—	
Interest on S. Bank	2,928.55	Cash in Bank	29,638.09	
Magazine sub./ proceedings	325.00	F.D.R. in Hand	2,53,800.00	
Grand Total	3,26,549.87	Grand Total	3,26,549.87	

Certified that the above is correct picture of the finance of the Association, as reflected in the Account Books as on 31.3.1987.

Auditor's Note

The detailed account of the receipt and payments have been audited with reference to cash receipts issued and vouchers etc. and are certified to be correct.

Sd/-
(H.C. Sharma)
Treasurer
Indian Potato Assoc.

Sd/-
(A.P. Dudeja)
Senior Auditor (Retd.)
Indian Audit & Accounts
Department, Rama Cottage,
Shimla-171 001, H.P.

Sd/-
(R.A. Singh)
Secretary
Indian Potato Assoc.

**THE HIMACHAL PRADESH STATE COOPERATION
MARKETING AND CONSUMERS FEDERATION LIMITED
HEAD OFFICE, SHIMLA 171003**

INTRODUCTION

'HIMFED' is an Apex Organisation of consumer's and marketing cooperatives in Himachal Pradesh. It is registered on 30th June, 1952 with the Registrar of Cooperatives, H.P. The elected Management is committed to every possible endeavour to facilitate the producers and consumers.

'HIMFED' saves the farmers from the exploitation by the private traders and provide them reasonable price of their surplus agricultural/horticultural produce, viz. potatoes, ginger, wheat, paddy, apples and other fresh vegetables. We undertake the marketing and forwarding of various items and provide good competitive rates and ensure timely payments to them.

'HIMFED' is dealing in seed potato since its inception. It provides better marketing facilities for the seed potato. We also act as an agent of the state govt. when-ever support price is announced. We market the seed potato in various parts of the country including hilly states such as Manipur, Nagaland, Tripura, Arunachal etc. The farmers of these states are also served by 'Himfed' by providing them better quality seed directly procured from the growers in Himachal Pradesh and the net result so far as yield is concerned has been very encouraging and every year the demand for certified seed is growing in various states for Himachal seed potato. We sell directly to the farmers through the State Government and through a net work of cooperatives all over the country.

BUSINESS TURNOVER

The business turnover has increased from Rs. 840.78 lacs from 1981-82 to Rs. 2300.00 lacs in the year, 1986-87.

(Sita Ram Sharma)
Chairman

(Diljeet Singh)
Managing Director

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(Registered under the Societies Registration Act XXI, 1960)

The Society was founded in 1974 with the objectives

- (1) To advance the cause of potato research and development, culture and utilization
- (2) Provide opportunity for personal contact and fellowship among workers in different fields embracing the potato
- (3) Hold periodical conferences, symposia, workshops, seminars, etc.
- (4) Publishing books, reports, summaries of papers and other forms of scientific and technical literature, a potato News letter and the Journal of the Indian Potato Association.
- (5) Co-operate with institutions in India and abroad and societies having similar objectives and fields of activities.
- (6) Promote exchange of scientific and other information and develop other means of communication between the potato agriculture and Industry
- (7) Foster Regional and International cooperation/collaboration in attainment of the objectives outlined.

Journal of Indian Potato Association is published quarterly. The annual membership in the country is Rs. 40.00 (Rs. 25.00 for students) and U.S.\$ 15.00 or equivalent for members abroad (inclusive of sea-mail) and payable in advance. Life membership is Rs. 300.00 or U.S. \$ 90 00 (for foreign members). The annual subscription for organization is Rs 200.00 in India and U.S. \$ 40.00 or equivalent for other countries, post fee (sea-mail) and payable in advance. U.S.\$ 7.00 be charged extra (in advance) if copies are wanted by air mail. The membership/subscription dues should be sent in the form of bank draft (or through M.O) in the favour of the Indian Potato Association, Shimla. Please address all correspondence in this regard to the Secretary, Indian Potato Association, Central Potato Reserch Institute, Shimla 171001 (H.P) India.

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JOURNAL OF INDIAN POTATO ASSOCIATION**

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| 4. Name of individuals who
own the newspaper and
partnership or shareholders
holding more than one per cent
of total capital. | Indian Potato Association
Regn. No. 206/74 |

I, Dr. S.K. Bhattacharyya, hereby declare that the particular given above are true to the best of my knowledge and belief.

Dated : 22.7.1987

Sd/-
Dr. S.K. Bhattacharyya
Signature of Publisher