POLICY PAPER 47

Protected Agriculture in North-West Himalayas

NAAS

NATIONAL ACADEMY OF AGRICULTURAL SCIENCES, NEW DELHI
December 2010

CONVENER : **Dr Anwar Alam**, Vice-Chancellor, SKUAST-K, Shalimar, Srinagar (J&K)

EDITORS : **Dr Rajendra Prasad**

: **Dr P.S. Pathak**

CITATION : NAAS 2010. "Protected Agriculture in North-West Himalayas". Policy Paper No. 47, National Academy of Agricultural Sciences, New Delhi. pp 16.

PARTICIPANTS

1. Prof. Anwar Alam, Vice-Chancellor, SKUAST-K, Srinagar
2. Dr Pitam Chandra, Director, CIAE, Bhopal
3. Dr Pratab Ray Bhatnagar, Project Coordinator, AICRP-APA, Ludhiana
4. Mr K.S. Iyengar, Joint Secretary, NCPAH, New Delhi
5. Dr A.K. Srivastava, Head, VPKAS, Almora
6. Dr Balraj Singh, Principal Scientist I/c CPCT, IARI, New Delhi
7. Dr Shafiq A. Wani, Associate Director Research (Agri.), SKUAST-K, Srinagar
8. Dr F. A. Banday, Prof. & Head, Division of Pomology, SKUAST-K, Srinagar
9. Dr A.A. Siddique, Head, Division of Floriculture, SKUAST-K, Srinagar
10. Dr M. A. Mir, Head, Division of PHT, SKUAST-K, Srinagar
11. Dr Hafiza Ahsan, Professor, PHT, SKUAST-K, Srinagar
12. Dr G.A. Parray, Associate Director Research, SKUAST-K, RARS, Leh
13. Dr M. A. Chattoo, Head, Division of Olericulture, SKUAST-K, Srinagar
14. Dr Nayeema Jabeen, Associate Professor, Olericulture, SKUAST-K, Srinagar
15. Er J. N. Khan, Head, Division of Agricultural Engineering, SKUAST-K, Srinagar
16. Dr K.N. Qaiser, Associate Professor (Forestry), SKUAST-K, Srinagar
17. Dr A.H. Mughal, I/c RARSS, SKUAST-K, Kargil
18. Er R. M. Shukla, Assistant Professor, AICRP on APA, SKUAST-K, Srinagar
19. Mr K.A. Qasba, Dy. Director Agriculture, GoJK, Srinagar
20. Er Mubashir Qadiri, AEE (R&R), SKUAST-K, Srinagar

Published by Mr H.C. Pathak, Executive Secretary on behalf of

NATIONAL ACADEMY OF AGRICULTURAL SCIENCES

NASC, Dev Prakash Shastry Marg, New Delhi - 110 012
Tel: (011) 25846051-52; Fax: (011) 25846054
Email: naas@vsnl.com; Web site: http://www.naasindia.org

Protected Agriculture in North-West Himalayas

1. PREAMBLE

North-West Himalayas are comprised of states of Jammu and Kashmir (J & K), Himachal Pradesh (HP) and Uttarakhand (UA). It is mountainous region transected by a number of mountain ranges, rivers and rivulets originating from the region. Its physiography is highly undulating with steep slopes with erodible but fertile soils, sub-tropical, intermediate hills, temperate-valleys and high hills, very high hills and cold arids. Severe and prolonged winter with sub-zero temperature brings agriculture to almost standstill, fruit trees shed their leaves and go under hibernation and livestock experiences severe morbidity and mortality. There is acute food and feed shortage and nutritional scarcity during winter months.

Average landholdings are steadily declining. Average land holding in J & K has comedown to 0.75 ha as against the national average of 1.37 ha which is likely to come down further to about 0.44 ha as compared to national average of 0.92 ha by 2025. Situation is just slightly better in HP and UA. Sources of livelihood are limited; over two-third of the rural people subsist on agri-horti-livestock husbandry (Table 1). Irrigation is limited and difficult; as a result productivity of crops and commodities is much lower than the potentials that exist. Consequently region is food and nutrition deficient. Short growing seasons and severity of winter at times does not allow maturity of cereals, pulses, and oilseed crops. Production levels are lower than the demands except in fruits and off season vegetables.

Room for horizontal expansion is very little and the only available option is vertical expansion thorough increased productivity and cropping intensity using modern methods like protected intensive farming employing plant environment control measures, quality seeds, fertilizer, irrigation and plant protection. Protected agriculture is more relevant in this region than in other parts of the country. Research and demonstrations have yielded very good results from mulching, cloches, low and walking tunnels and polyhouses specially for early nursery raising, vegetative propagation, production of offseason vegetable, fruits, flowers, medicinal and aromatic plants.

Protected farming is economically more rewarding in production of high value, low volume crops, seeds and planting materials, off season fruits and vegetables. With appropriate structures and plant environment control measures the constraints of environment prevalent in the region can be overcome allowing almost year-round cultivation, increased productivity by 25-100% and in certain cases even more, as well as conservation of irrigation water by 25-50%. Protected farming offers itself as alternate farming method with much higher carrying capacity. It requires intensive R & D to advance the technology and its profitability and promotional schemes with built in capital incentives looking to the capital constraints with the farmers.

Table 1. Agri-ecological zone and livelihood production systems in the North-Western Himalayan region.

Zones	Climates, altitude (m, amsl)	Livelihood production system	Parts of the state covered		
			Jammu & Kashmir	Himachal Pradesh	Uttarakhand
Zone I Sub-mountain Low Hills	Sub-tropical 200-800	Agri-livestock-fish-horticulture	Jammu and plains of Udhampur	Una, Bilaspur, Hamirpur and parts of Sirmaur, Kangra, Solan and Chamba districts	Parts of Pauri Garhwal, Udham Singh Nagar, and Dehra Dun, Almora and Pithoragarh districts
Zone II Mid-Hills	Sub-humid 801-1800	Agri- horti-livestock- fish	Hilly areas of Doda, Udhampur, Rajauri and Poonch districts	Kangra Tehsils of Palampur and Shimla district, and parts of Mandi, Solan, Kullu, Chamba and Sirmaur	Parts of all districts
Zone III High Hills	Temperate 1801-2200	Agri- horti-livestock-pasture-fish	Srinagar, Budgam, Anantnag, Pulwama, Baramula, Bandipora Ganderbal, Kupwara, Leh and Kargil districts	Shimla district (except Rampur tehsil) and parts of Kullu, Solan, Chamba, Mandi, Kangra and Sirmaur district	Major parts of Pithoragarh Uttarkashi and small part of Chamoli and Tehri Garhwal
Zone IV Very High Hills	Temperate Cold Arids, >2200	Livestock-silvipasture-agriculture	Leh and Kargil districts	Kinnaur, Lahaul and Spiti, and Pangi and Bharmour tehsils	Parts of Uttarkashi, Chamoli, Pithoragarh and Almora districts

2. FOOD AND NUTRITIONAL SECURITY STATUS IN NW-HIMALAYAS

Varied agro-ecological situations (Table 1) ranging from sub-tropical to temperate offer vast scope of production of foodgrains, oilseeds, fruits, vegetables, flowers, ornamental herbage, medicinal and aromatic plants, livestock husbandry and fishery. There are serious constraints of terrain, topography, severe prolonged winter, transport, and marketing etc. The region as a whole is food deficit (Table 2) in terms of cereals, pulses and oilseeds; the average productivity is lower than national averages. However, results of Front Line Demonstration (FLDs) indicate that self sufficiency can be easily achieved through HYV, hybrids; increasing the cropping intensity, use of fertilizer, protective irrigation, plant protection measures and post-harvest management. Region is surplus in fruits and vegetables (Table 3), which fetch substantial cash through export to other states except in winter months when there is shortage of vegetables because of climate constraints. Region also produces loose and cut flowers (Table 4) and markets it locally as well as exports to major cities in the plains. However, potential is not fully utilized. Profits are much more in off season horticultural products, provided climatic constraints are overcome adopting protected farming for advanced nursery and planting materials, and production of vegetables, flowers and fruits. Region has favourable climatic conditions for production of quality horticultural products which needs to be fully exploited both for domestic and export markets.

Table 2. Foodgrains, pulses and oilseeds requirement, production, productivity and surplus/deficit in NW Himalayas.

State	Requirement ('000 t)	Production ('000 t)	Productivity (kg/ha)	Surplus/deficit ('000 t)
Food Grains				
Uttarakhand	1494	1724	1672.20	+230.00
Himachal Pradesh	1071	1399	1733.20	+328.00
Jammu and Kashmir	1774	1375	1524.00	-399.00
Total	**4339**	**4498**	**1641.40**	**+159.00**
Pulses				
Uttarakhand	154.8	29.0	690.5	-125.8
Himachal Pradesh	110.9	9.0	307.2	-101.9
Jammu and Kashmir	183.8	12.8	460.4	-171.0
Total	**449.5**	**50.8**	**512.6**	**-398.7**
Oilseeds				
Uttarakhand	309.5	34.0	918.9	-275.5
Himachal Pradesh	221.8	9.2	567.9	-212.6
Jammu and Kashmir	367.6	41.1	541.5	-326.5
Total	**898.9**	**84.3**	**653.0**	**-814.6**

Source: FAI (2005)

Table 3. Fruits and vegetable requirement, production, productivity and surplus/ deficit in NW Himalayas.

State	Requirement ('000 t)	Production ('000 t)	Productivity (kg/ha)	Surplus/deficit ('000 t)
Fruits				
Uttarakhand	186.6	717.9	4200	+531.3
Himachal Pradesh	133.7	713.0	3500	+579.3
Jammu and Kashmir	221.5	1435.9	7400	+1214.4
Total	**541.8**	**2866.8**	**5030**	**+2325.0**
Vegetables				
Uttarakhand	928.5	1036.2	1290	+107.7
Himachal Pradesh	665.5	1150.7	1810	+485.2
Jammu and Kashmir	1102.7	1238.1	2110	+135.4
Total	**2696.7**	**3425.0**	**1736**	**+728.3**

Source: NHB (2009)

Table 4. Area and production of flowers in the North-Western Himalayan States.

State	Area in 000 ha		Production (Loose in 000 roots; cut in Lakh)			
	2006-07	2007-08	2006-07		2007-08	
			Loose	Cut	Loose	Cut
Uttarakhand	0.71	0.90	0.46	1229.74	0.70	1455.45
Himachal Pradesh	0.58	0.58	3.63	530.75	3.40	565.55
Jammu & Kashmir	0.33	0.33	1.34	218.00	1.34	218.00
Total	**1.62**	**1.81**	**5.43**	**1978.49**	**5.44**	**2239.00**

Source: NHB (2008)

Hill people are largely non-vegetarian, especially in J & K where more than half the meat, eggs, poultry, and fish consumed comes from neighboring states causing severe drain on the state's economy. If the highways are blocked due to landslides and snow, acute shortages are experienced and prices shoot up. Major constraints in production of animal products are lack of feeds and fodders as well as shelter and environment control particularly during winter months that result in drastic drop in domestic production of milk, meat, eggs, poultry and fish. During winter months there is high morbidity and mortality in livestock. Feeds largely come from outside the state and as a result are costlier. A quantum jump in production and productivity of maize can dramatically change scenario in production of animal products. Range and pasture lands are overgrazed and colonized by toxic weeds, reducing their carrying capacity. Green fodder production, haymaking and silaging, feed blocks etc. can mitigate the situation. Production of fodder oats, and alfa-alfa (lucerne) has caught the imagination of the farmers. Backyard poultry, duckry are also receiving attention; their promotion needs hatcheries that supply vaccinated chicks and ducklings in easy reaches of the farmers.

3. CLIMATIC CONSTRAINTS OF N-W HIMALAYAS

Altitudes in the N-W Himalayas range between 200 - > 5000 m-amsl. Winters in N-W Himalayas are severe and prolonged restricting agricultural season from about 7 to 2.5 months or less (Table 5). Sub-freezing temperatures results in snowfall at higher altitudes (1500-5500 m-amsl), it could be dry snow or wet along with rainfall. Heavy snowfall causes snow avalanches damaging field crops and orchards. Temperatures near freezing cause hailstorms, and frost damage to crops at high altitudes, say Leh (3850 m-amsl), where permafrost with soil frozen in upper layers occurs. As a result large tracts remain mono-cropped with cold tolerant short duration varieties. Usually, shorter the duration of a crop lower is the yield. Delay in sowing / transplanting or long duration crop varieties do not allow grain maturity before winter sets in. At 3000 m-amsl altitude ambient minimum temperatures are below or near freezing temperatures for almost five months generally associated with relative humidity in the range of 45 – 60%. In Leh (3850 m-amsl) average minimum ambient temperatures are -2.3 to -16.4 ºC during October-March and near freezing in April.

Table 5. Agricultural seasons at different altitudes

Altitude (m-amsl)*	Duration	Month
2670	April-October	7.0
3000	May to mid October	5.5
3300	Mid May-Mid September	4.0
4000	Mid June-August	2.5

* M-amsl – metres above mean sea level.

4. PROTECTED AGRICULTURE

It refers to agriculture with human interventions that create favourable conditions around the cultivated plants or animals offsetting the detrimental effects of prevailing biotic and abiotic factors. Plants in open field conditions experience short cropping season, unfavourable climatic conditions (too cold, too hot, too dry and cloudy ambient) impairing photosynthetic activities, vulnerable to predators, pests, weeds, depleted soil moisture and plant nutrients. In protected agriculture one or more of these factors are controlled or altered, to the advantage of plants or animals, where usually factors such as temperature, CO_2 concentration, relative humidity, access to insect and pest etc., are controlled to desirable limits. The factors controlled and range of control is decided by devises chosen and fitted on the structure. For economic reasons, protection or control is provided against the most significant stresses. Structures and environment control measurers employed isolate this cultivated space allowing cultivation in unfavourable ambient conditions in reasonably close to optimal conditions and offers several advantages, as given below:

- Crop and animal production with high productivity under unfavourable agro-climatic conditions.
- Productivity levels could be significantly higher (sometimes two-three times of that in open field agriculture).
- Quality of produce is usually superior because of isolation and controls.
- Higher input use efficiencies are achieved in the production of plant and animal products.
- Income per unit area significantly increases.
- Year-round production.

The Netherlands (Holland) has a long tradition of protected cultivation under glass shielded greenhouses growing flowers / ornamentals and vegetables in equal proportion. Globally there are about 20 Mha under protected cultivation and is still on the rise. However, in Europe, Spain is the leader with 51,000 ha mostly under low cost polyhouses, about 150,000 ha under plastic mulches and over 20,000 ha under low tunnels and floating covers. In Asia, China has the largest area under protected cultivation; over 2.5 Mha under polyhouses/greenhouse, 9.6 Mha under plastic mulches, 0.9 Mha under low tunnels and floating covers. Japan has about 54,000 ha under greenhouses/polyhouses of which about 11,000 ha are under fruit crops. Brinjal, tomatoes, cucumbers, pumpkins, green pepper, strawberries, water melons, and lettuce are grown in greenhouses in Japan. India is way behind. Declining landholdings demand greater attention towards protected cultivation particularly low cost polyhouses (currently only 1000 ha), low tunnels and plastic mulching. There are two Indian standards (IS 14461: 1997 and IS 14462: 1997) formulated for better understanding and construction of Quonset shape 4 x 20 m, low cost greenhouses. An Indian standard (IS 14485: 1998) has been formulated for ventilation, heating, and cooling in polyhouses.

4.1 Principles

Basic principles involved in protected agriculture are greenhouse effect for heating cultivated space using sunrays and ventilation for cooling and air CO_2 regulation. Cultivated area is isolated and covered with plastic film or glass which is transparent to incoming short wave radiation from the sun impinging on outer surface but opaque (partially) to emergent long wave infrared radiation from soil, plant and structural surfaces, thereby trapping the heat. As a result enclosed space maintains higher temperature than the ambient. However, trapped heat is gradually dissipated through conduction, convection/ventilation and radiation. By incorporating heat sinks, reduced ventilation and application of radiation shields either rate of cooling is slowed down or a supplemental heat source placed inside. Fig 1 depicts energy exchange in a greenhouse. In summer months when sun is too bright and ambient too hot, shading, natural / forced ventilation, evaporative cooling prevent excessive temperature buildup.

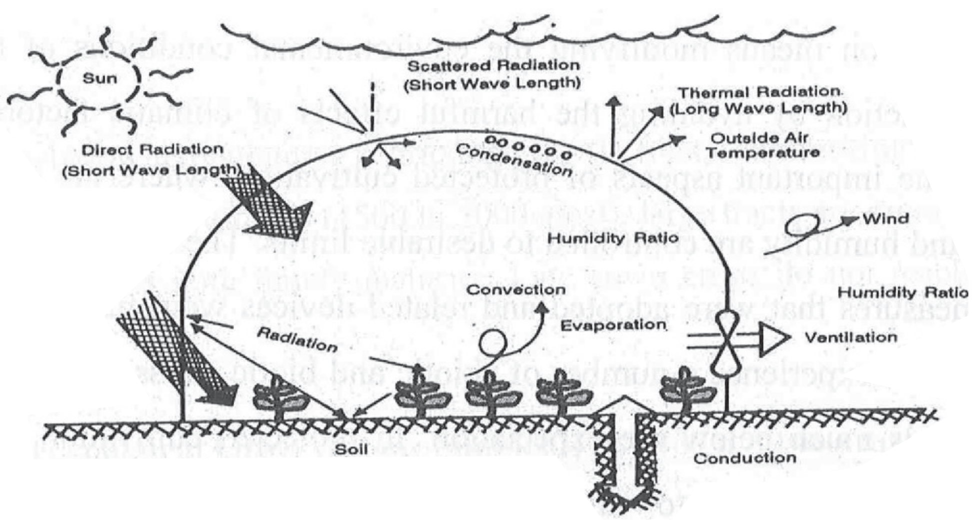

Fig 1. Schematic diagram of energy exchange in a greenhouse

4.2 Methods of Protected Cultivation

The following are the major protected cultivation methods in vogue:

1. Mulching
2. Floating Covers
3. Low tunnels / Row Covers
4. Cloches
5. Polyhouses / Greenhouses

4.2.1 Mulching

It is a practice of covering soil around cultivated plants to make conditions more favourable to the plants by conserving soil moisture, maintaining higher soil temperature, controlling weeds and keeping root zone more friable allowing soil aeration conducive to soil microflora and root growth etc. Covering materials could be natural, like leaves, straw, sawdust, peat moss, compost, gravel etc or synthetic, like polyethylene and PVC of different colours (generally black) and thickness depending upon ambient conditions and effects desired (Fig. 2). Plastic mulches have several advantages,

- Soil moisture is better conserved.
- Weeds are effectively controlled by blocking sun light.
- Soil fumigation is more effective.
- CO_2 enrichment around plant root zone.
- Permits cleaner crop produce.
- Early crops, higher yields and more income.

A large variety of crops could be brought under plastic mulches. All fruit crops, vegetables, sugarcane, cotton, plantation crops, groundnut, tobacco have been successfully mulched with plastics films. In China, even maize and rice are plastic mulched. Significant yield advantages (10 – 100%) are reported by mulching. Used plastic mulches are collected for recycling and obtaining heat energy for power generation etc. Alternatively, photo and bio-degradable plastic mulches are under development to avoid disposal problem.

Fig 2. Plastic mulching

4.2.2 Floating Row Covers

A Floating Row Cover is a plastic film fabric used without any mechanical support to protect crops from insect vectors, sucking pests, hoppers and beetles. Floating covers are made of spun bonded or non-woven fabric of 10 – 50 g/m^2 density. Either single rows or a number of rows at a time are covered. Heavier covers of densities higher than 30 g/m^2 are used primarily for frost and freeze protection. The edges are secured by burying in the soil. For self pollinated crops, leafy vegetables, the floating covers can be had for the entire duration of the crops. The crops of musk melon, tomato, pea, carrot, cabbage, leafy vegetables, lettuce, green beans, cucumbers, watermelon, squash, and radish are grown under floating covers.

4.2.3 Low Tunnels / Row Covers

Low tunnels generally cover rows of plants in the field providing protection against low temperatures and frost, winds and insect pests. Clear plastic films or nets are stretched over low (up to 1.0 m high) hoops made of steel wires, bamboo strips or cane (Fig. 3). Polyethylene films of about 50 micron thickness with ventilating holes (4% of surface area) are used. Sometimes PVC films are also used. Recently use of non-woven spun bonded porous lighter films have also come in practice. Low tunnel provides a passive control of plant microclimate. Plastic mulches and drip irrigation in conjunction with low tunnels have better effect. Low tunnels permit early crops with significantly higher yields of melons, cucumber, tomato, strawberry, capsicum, beans, summer squash etc.

Fig 3. Low tunnels

4.2.4 Cloches

A cloche is a protective enclosure consisting of a structural frame and transparent or translucent glazing material for individual plants providing protection to young transplants in kitchengardens, orchards and forests (Fig. 4). After the plant is well established cloches are removed. Provision of natural ventilation is required to avoid excessive high temperature in clear sunny conditions.

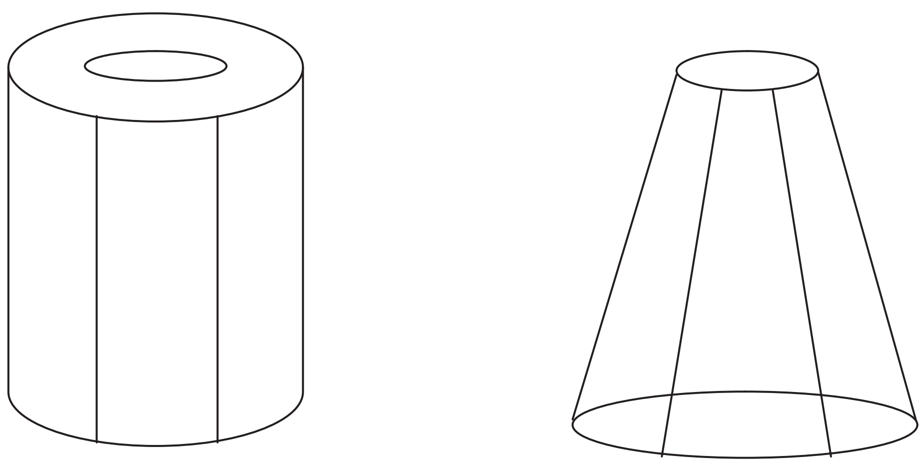

Fig 4. Cloches

4.2.5 Polyhouse / Greenhouse

It is a framed or inflated structure using transparent or translucent cover that creates greenhouse effect, allowing at least partial control on crop microclimate and is large enough to permit a person to work inside (Fig. 5 & 6). The air temperature rise inside a polyhouse/greenhouse during winter is utilized to grow nurseries, planting materials and crops without supplementary heat. The enclosed space through controlled ventilation permits enrichment of air inside with higher CO_2 concentration which enhances crop productivity. Relative humidity and temperatures can be raised or lowered than ambient through shading and evaporative cooling or air-conditioning.

If economics permits, practically any crop can be grown in greenhouses/polyhouses. However, off season vegetables, certain fruits, flowers and ornamental plants and nurseries are found quite remunerative. Bananas, strawberries, grapes, peaches, plums etc have also been grown in greenhouses. It is a very intensive method of cultivation that has very high productivity, per unit area, yields superior quality exportable produce with higher market prices.

Fig 5. Greenhouse for colder regions in northern hemisphere

Fig. 6: A multi-span greenhouse

4.2.5.1 Design and Construction

A polyhouse/greenhouse can be Quonset, gable or gothic in shape with frame made out of locally available materials, steel or aluminum. In cold arid Ladakh where very high cold winds prevail, polyhouses are made with mud-wall or sundried brick wall on three sides, southern side is kept sloping, over which polyethylene cladding is created and is supported on wooden or bamboo frames. Trench Type Polyhouses of suitable dimensions (5 – 10 x 3 – 4 x 1 m) with plastic cladding on the top supported over wooden poles / GI pipes are also under promotion in Ladakh. Polyhouses are constructed using GI pipe of 25-75 mm diameter with a wall thickness of 2 mm. These structures are fastened by welding, nut and bolts or clamped. Foundation for posts, size of hoops and perlins are worked out on engineering principles.

Good covering material (cladding) is essential to ensure a good life and to achieve good greenhouse effect. Mostly UV stabilized 200 micron (800 gauge) low density polyethylene (LDPE) films are preferred. Polymer chemistry offers a wide range of films suitable for different conditions – diffused or relatively translucent films, cross-laminated, anti-fog, anti-drip, anti-sulphur types. Films are secured on frame such that they do not flutter in wind otherwise it wears and gets torn-off requiring repair or replacement. Insect-proof nets and shading materials are employed for vegetable cultivation in summer months instead plastic film.

4.2.5.2 Climate Control inside Polyhouse

Optimum temperature for most of the plants (vegetables & flowers) is in the range of 25-30 ºC with a 60-80% RH and a CO_2 concentration of 600-700 ppm. Greenhouse effect increases air temperature inside the polyhouse which is generally beneficial for crops in cold areas like Himalayan region. Under extremely cold conditions supplemental heating may be needed. In India, particularly during summer it is cooling that is more often required than heating. Temperature inside the polyhouse can be lowered by natural and forced ventilation, evaporative cooling using fan and pad system, misting, shading etc. Polyhouses without any ventilation or cooling device maintain 6-10 ºC higher temperature than ambient during day time. Natural ventilation can reduce it by 2 - 5 ºC. However, if forced ventilation is in place inside temperature may be only 1-2 ºC higher than ambient. For further reduction shading and/or misting can be employed. Evaporative cooling can however, bring down air temperature inside lower than the ambient, net cooling will depend upon RH of the ambient air. IS 144485:1998 provides guidelines for ventilation, cooling and heating in polyhouses. During summer months insect-proof nets and shading materials are found helpful and widely used. In extreme hot weather misting inside keeps temperatures favourable.

4.2.5.3 Productivity in Polyhouses

Vegetable Crops

In experiments in India on vegetable production under polyhouses has given typical single crop yields as follow: Cucumber 25 kg/m^2, Tomato 14 kg/m^2, Capsicum 12 kg/m^2, Broccoli 1.5 kg/m^2.

Productivity of protected cultivation of vegetables using low cost polyhouses at about 3000 m-amsl altitude has been 40% to > 300% of outdoor farming. Recorded yield of some of the vegetable crops are summer-squash 10.50 kg/m^2, cucumber 7.5 kg/m^2, brinjal 5.15 kg/m^2, tomato 3.02 kg/m^2, beans 2.51 kg/m^2, spinach 1.02 kg/m^2, pea 0.93 kg/m^2, coriander leaves 0.74 kg/m^2.

Not only crop productivity per unit area is increased several times but also productivity per unit volume of water is increased substantially inside polyhouses.

High Altitudes : As of now low cost polyhouses are being used for vegetable production in high hills. Cost effective designs of polyhouses have been standardized which maintain about 8-10 ^{O}C higher temperature than ambient without ventilation. Natural and forced ventilation lower down the inside temperature to about 2-3 ºC higher than ambient.

Cold Arids : Cold arids of Ladakh, Lahol and Spiti experience freezing temperatures during winter months accompanied with strong winds making open field cultivation too difficult. Low cost mud-walled polyhouses have come in use. DRDO and SKUAST-K have developed, demonstrated and popularized Trench Type Polyhouses using transparent film during day time and black film during night for collection and conservation of solar energy at the same time providing protection from winds. Wooden, bamboo and GI pipe framed low cost polyhouses have also been successfully tried. Protected cultivation of vegetables is possible even during winter months like leafy vegetables, cucurbits, cabbage, cauliflower, knol-khol, turnips, broccoli etc.

Plastic mulching using black polyethylene is also possible for cole crops, tomato, capsicum with advantages of higher productivity, water conservation, weed control and early harvest. It also enables cucurbit cultivation in open field.

Fruit Crops

Fertigated strawberry cultivation under low cost polyhouse has been studied as compared to open field plastic mulched cultivation at SKUAST-K, Shalimar, Srinagar. Fruit picking inside polyhouses started about 45 days earlier than outdoors and productivity was more than double. Total soluble solids (TSS) content was also high – 7.75% in polyhouse fruits as compared to 4.78% in open field berries. However, size was relatively smaller (39 g/berry) than open field (47 g/berry).

Raising Nurseries and Vegetative Propagation

Off-season vegetable cultivation is an economically rewarding activity in N-W Himalaya region. Vegetable seeds are not only costly but need 18-20 ºC or even higher temperature which may be reached in late March or early April which is too late for early vegetable crop. For good seed germination, controlled conditions are needed. Under polyhouse conditions seedlings can be raised with high germination rates late February and early March, which allow advancement of crop by 1-1.5 months. Vegetable nursery raising under protected condition is a paying proposition and is becoming popular especially in the hilly regions. Micro-propagated plant hardening, vegetative propagation and grafting / budding, rooting of cuttings has much higher success rate in polyhouse condition.

Animal Products

Animal production systems using well-designed dairy sheds with milking parlors, poultry houses with hatchery and brooder houses, piggery and duckry units are there in organized sector. Animals are protected from extreme heat and cold through environment control measures similar to these employed for protected crops. However, at farmers level, animal shelter and environment control measures are non-existent or very primitive.

Recommendations

A. Research

1. Development of appropriate, efficient and affordable protected agricultural structures for crops and animals with appropriate, durable, efficient and economical cladding materials.

2. Identification and development of suitable varieties of crops for protected cultivation both for high value vegetables and cut-flowers. Already a few varieties are identified like Cherry tomato, Namadhari and Normal (GS-600, VLT-4) in tomato; Keyan and Satis cucumber (Nanhans); Capsi-3, Indira (Red), Orobellee, Bombay (Red), Sawrna (Yellow), Natasha (Red extra-lobe) in capsicum, and Australian Green, Pusa Alankar, Punjab Chapan Kadu-1, Chand (hybrid) in summer-squash.

3. Development of affordable agro-practices specific to protected cultivation particularly with respect to IPM, INM (water soluble fertilizers), IWM, Best Management Practices (BMP), and package of practice for organic farming.

4. Standardization of crop nursery practices under protected environment to make maximum use of available space and opportunity.

5. Development of post-harvest practices for handling, grading, packaging, transport and short term storage of produce from protected cultivation.

6. Development of tools, implements and machines for facilitating crop operations under protected cultivation e.g. laying of mulches, polytunnels etc.

7. Designing of location and crop specific structures for energy efficient micro-climate control for maximum crop productivity. This includes development of intelligent control systems for micro-climate maintenance.

8. Multi-tier protected farming techniques need to be developed to maximize productivity per unit of ground area to cope up with growing demands of vegetables, fruits, flowers, medicinal and aromatic plants in declining land holding scenario.

B. Development

1. Human resource development through training of trainers, field extension workers, NGOs, village leaders and farmers. Rural artisans and craftsmen need to be trained in construction and maintenance of plasticulture equipment and structure.

2. Large scale demonstration of proven protected cultivation practices in potential areas. Launching of schemes at state and central level with built-in incentives for the designs recommended by research institutions.

3. Create post-harvest handling, transport, storage and marketing infrastructure for protected cultivation produce ensuring better returns to farmers.

4. Networking of farmers/Self Help Groups (SHGs) for production, handling and marketing of produce from protected agriculture for domestic as well as export markets.

C. Policy

1. Create awareness and enabling environment for economic prosperity of stakeholders of protected agriculture.

2. Assured availability of cladding materials, other essential inputs-seeds, water soluble fertilizers, pesticides etc. at the divisional level.

3. Precision Farm Development Centres (PFDCs) should be well equipped and should create a role for themselves in protected agriculture.

4. State Agricultural Universities and KVKs in the region need to lay emphasis on teaching, research and extension of protected cultivation as major and important step towards strengthening livelihood base of small landholders.

5. Link the identified promotional schemes for protected agriculture with already existing State/National programmes. RKVY funds should be mobilized for promotion of protected farming in North-West Himalayan region.

EXECUTIVE COUNCIL 2010

NAAS Documents on Policy Issues*

1.	Agricultural Scientist's Perceptions on National Water Policy	- 1995
2.	Fertilizer Policy Issues (2000-2025)	- 1997
3.	Harnessing and Management of Water Resources for Enhancing Agricultural Production in the Eastern Region	- 1998
4.	Conservation, Management and use of Agro-biodiversity	- 1998
5.	Sustainable Agricultural Export	- 1999
6.	Reorienting Land Grant System of Agricultural Education in India	- 1999
7.	Diversification of Agriculture for Human Nutrition	- 2001
8.	Sustainable Fisheries and Aquaculture for Nutritional Security	- 2001
9.	Strategies for Agricultural Research in the North-East	- 2001
10.	Globalization of Agriculture: R & D in India	- 2001
11.	Empowerment of Women in Agriculture	- 2001
12.	Sanitary and Phytosanitary Agreement of the World Trade Organization – Advantage India	- 2001
13.	Hi-Tech Horticulture in India	- 2001
14.	Conservation and Management of Genetic Resources of Livestock	- 2001
15.	Prioritization of Agricultural Research	- 2001
16.	Agriculture-Industry Interface: Value Added Farm Products	- 2002
17.	Scientists' Views on Good Governance of An Agricultural Research Organization	- 2002
18.	Agricultural Policy: Redesigning R & D to Achieve It's Objectives	- 2002
19.	Intellectual Property Rights in Agriculture	- 2003
20.	Dichotomy Between Grain Surplus and Widespread Endemic Hunger	- 2003
21.	Priorities of Research and Human Resource Development in Fisheries Biotechnology	- 2003
22.	Seaweed Cultivation and Utilization	- 2003
23.	Export Potential of Dairy Products	- 2003
24.	Biosafety of Transgenic Rice	- 2003
25.	Stakeholders' Perceptions On Employment Oriented Agricultural Education	- 2004
26.	Peri-Urban Vegetable Cultivation in the NCR Delhi	- 2004
27.	Disaster Management in Agriculture	- 2004
28.	Impact of Inter River Basin Linkages on Fisheries	- 2004
29.	Transgenic Crops and Biosafety Issues Related to Their Commercialization In India	- 2004
30.	Organic Farming: Approaches and Possibilities in the Context of Indian Agriculture	- 2005
31.	Redefining Agricultural Education and Extension System in Changed Scenario	- 2005
32.	Emerging Issues in Water Management – The Question of Ownership	- 2005
33.	Policy Options for Efficient Nitrogen Use	- 2005
34.	Guidelines for Improving the Quality of Indian Journals & Professional Societies in Agriculture and Allied Sciences	- 2006
35.	Low and Declining Crop Response to Fertilizers	- 2006
36.	Belowground Biodiversity in Relation to Cropping Systems	- 2006
37.	Employment Opportunities in Farm and Non-Farm Sectors Through Technological Interventions with Emphasis on Primary Value Addition	- 2006
38.	WTO and Indian Agriculture: Implications for Policy and R&D	- 2006
39.	Innovations in Rural Institutions: Driver for Agricultural Prosperity	- 2007
40.	High Value Agriculture in India: Prospects and Policies	- 2008
41.	Sustainable Energy for Rural India	- 2008
42.	Crop Response and Nutrient Ratio	- 2009
43.	Antibiotics in Manure and Soil – A Grave Threat to Human and Animal Health	- 2010
44.	Plant Quarantine including Internal Quarantine Strategies in View of Onslaught of Diseases and Insect Pests	- 2010
45.	Agrochemicals Management: Issues and Strategies	- 2010
46.	Veterinary Vaccines and Diagnostics	- 2010

* For details visit web site: http://www.naasindia.org