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ICAR NEWS

A SCIENCE AND TECHNOLOGY NEWSLETTER

RESEARCH UPDATE

PROMISING TECHNOLOGIES

Fruit Russeting in 'Gale Gala' apple

Apple (*Malus x domestica* Borkh.) is the most important cash crop of the hill temperate world. In Himachal, it constitutes about 49% of the total area under cultivation and 85% of total fruit production, thereby, generating an economy of around 523 million US dollars. The Kinnaur, a tough terrain tribal district stretching towards Tibetan border, represents dry temperate region in north-west Himalayas.

Apple farming (86% of total fruits area) has tremendously resulted in amelioration and transforming the economy of tribal district in a big way. The growers are primarily using traditional orchard fertilization in late autumn to early spring. Increasing fertilizer cost and its scarce availability to meet the real fruit crop demand for specific nutrients indicated low productivity of orchards.

Russet free apples

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A view of apples orchards in dry temperate areas

Nutrient mining from the soil on continuous basis coupled with imbalanced use of fertilizers has resulted in increasing nutrient deficiencies which is limiting crop response to NPK fertilization. Development of high yielding systems will likely exacerbate the problem of Ca, Mg and micronutrient deficiencies, due to the application of large amount of NPK to achieve higher yield targets.

Russeting is one of the more important horticultural problems in apples. It is caused by different stimuli on the fruit surface including fluctuating weather conditions especially frost around the time of bloom, high humidity and precipitation, particularly during the period from 15-20 days after bloom, low temperature during fruit set, pesticide application at high temperature and incompatible pesticide mixtures. Russeting is a surface defect on fruits and is a major concern for apple growers worldwide. Exposure of the hypodermal cells beneath micro-cracks to air results in formation of a cork cambium known as russet. It reduces the value of apple and causes substantial economic losses to orchardists. The customized fertilizers, multi-nutrient carriers to crop fertilization, are designed for foliar application containing Ca, Mg, Fe, Cu, Zn, Mn, both in inorganic and/ or organic sources, satisfying crop nutritional needs, specific to its site, and stage and validated by a scientific crop model.

The effect of integrated fertilization (100, 80, 60 and 40% of NPK) along with 'water soluble customized nutrients' (WSCN) foliar formulation on fruit russet control was evaluated (Table 1). It was seen that all applied concentrations of WSCN reduced russeting in 'Gale Gala' apple significantly. The pest and disease management programme was also adopted to manage

A full bearing 'Gale Gala' apple tree

Inorganic fertilizer inputs used in 'Gale Gala' apple

Fertilizer factor	Fertilization Level*				Treatment (T)	Rate		WSCN Spray version and schedule (g tree^{-1})		
	100%	80%	60%	40%				15 DAPF	30 DAPF	45 DAPF
N	560	446	336	224	T_1	100% NPK	(+)	$WSCN_{100}$+$urea_{25}$	$WSCN_{100}$	$WSCN_{100}$
P	280	224	168	112	T_2	80% NPK	(+)	$WSCN_{100}$+ $urea_{25}$	No spray	$WSCN_{100}$
K	560	446	336	224	T_3	60% NPK	(+)	$WSCN_{75}$+ $urea_{25}$	$WSCN_{75}$	$WSCN_{75}$
WSCN (foliar, ww)	K_2O:S:Mg:Ca:Zn:B (6:11:5:0.3:0.3:0.4)				T_4	40% NPK	(+)	$WSCN_{75}$+ $urea_{25}$	No spray	$WSCN_{75}$
Mode of N supply	1/3 of dose in January, 2/3 of dose in April				Control	RDF-NPK	(+)	Water spray only		

DAPF, days after petal fall; $WSCN_{100}$, 100 g tree^{-1}; $WSCN_{75}$, 75 g tree^{-1}; $urea_{25}$, 25 g tree^{-1}

Spur and yield attributes of EMLA.111 'Gale Gala' apple trees affected by WSCN formulations

Treatment	Spur length (mm)	Spur thickness (mm)	Fruit set (%)	Fruit drop (%)	Yield (kg tree^{-1})
T_1	36.7	10.7	49.6	9.81	34.9
T_2	35.2	10.3	44.5	9.69	39.1
T_3	49.6	15.5	64.8	9.14	41.7
T_4	34.9	11.4	58.4	9.84	36.2
Control	25.4	9.2	36.1	9.87	29.4

DOP indexing determined from apple leaf nutrients on EMLA.111 at various WSCN formulations

Treatment	N	P	K	Ca	Mg	Fe	Cu	Zn	Mn
T_1	+33	+106	+123.3	-14	+16	-4.2	+7.5	+4	+4
T_2	+35	+126	+128.3	-12	+16	-8.8	+18	+3	+13.5
T_3	+36	+136	+140	-11.5	+36	4.5	+33.5	+16	+31
T_4	+33	+96	+115	-18	+24	-10.7	+11.5	+8.7	+19
Control	+31	+86	+113.3	-19	+12	-11.7	+3	-1	+3

apple pest-disease complex. EMLA.111 was the most suitable clonal rootstock, where, the rate of russeting on fruits was less irrespective of the WSCN tested. EMLA rootstock has also presented different degree of susceptibility to fruit russet and was more susceptible in early stage of development than those in later stages.

This research also appears in the cases of increase of spur traits, nutrient acquisition, fruit yield and quality characteristics. The increase is proportional to N-levels. Moderate N-doses plus PK-addition had also positive effects. The nutrient supply also increased vegetative traits in addition to generative parts. Foliar spray of water soluble customized nutrients in full bearing apple trees could be started at fifteen days interval after petal fall. Application of 60 % of recommended NPK traditional soil fertilization along with foliar application of 75 g WSCN +25 g urea at 15 days after petal fall +75 g WSCN at 30 and 45 days after petal fall in trees is the most effective combination. Using of customized foliar nutrients fertilization has also saved 40 % of traditional soil NPK fertilizers with improved fruit yield and quality. It is also confirmed that the period of maximum sensitivity to russeting occurrence between the second and fourth week after blooming, when the fruit diameter is between 15 to 30 mm. The DOP indexes also confirmed balanced leaf nutrient concentration at WSCN fluids application, which confirmed better adaptation to slightly acidic and sandy soils associated with higher tree vigour.

Advantages of customized foliar nutritive fluids

- Customized fertilizers (CFs) are compatible with existing farmers system, and hence will be comfortably accepted by fruit growers.

Russeted apples

- CFs use the fertilizers best management practices to maximize crop yields with minimum undesirable impacts on environment and human health.
- CFs provide site specific nutrient management for achieving maximum fertilizer use efficiency for the applied nutrient in a cost effective manner. Cost of CFs are same as that of normal fertilizers.
- CFs satisfy crop's nutritional demand, specific to area, soil and growth stage of plant.
- No need to buy micro-nutrient formulation at extra cost.
- CFs ensure improved Fertilizer Use Efficiency and thus, the distribution and availability of fertilizer will be better and crop growth stage specific.

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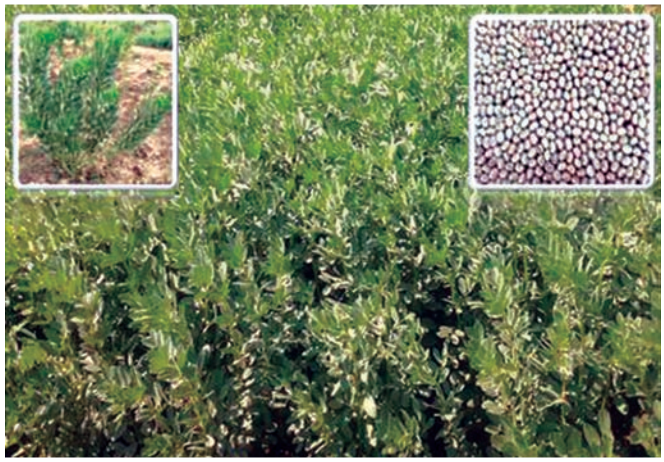
Swarna Suraksha and *Swarna Gaurav* developed

Since considerable area in Bihar is still under rainfed farming, hence keeping in view the importance of rainfed farming, *Swarna Suraksha* was developed mainly for the rainfed farming situation at ICAR Research Complex for Eastern Region, Patna.

as well as intercrop with potato, maize and other vegetable crop under irrigated condition. Hence, keeping in view the importance of faba bean in intercropping under irrigated condition; *Swarna Gaurav* was developed mainly for the irrigated ecology at ICAR RCER, Patna.

Swarna Suraksha : Boon for rainfed cultivation



Swarna Gaurav : High yielding low tannin faba bean

Seed production and distribution of two varieties of faba bean

Description of technology

The faba bean variety, Swarna Suraksha is a semi bushy type (70-90 cm), early duration (110-115 days), short bold grains (1,000 seed weight 270 g), drought tolerant, moderately resistant to major insect pest and diseases. Length of pod is 4.0-4.5 cm, average productivity 2.5 to 3.1 t/ha. Sweetness of the mature seeds is 10.9 TSS. Contents low of ant-nutritional factors tannin and phytate.

Applicability/ situations: Rainfed condition of Bihar Eastern UP and Jharkhand.

Intercropping is one of the main practices with potato, winter maize, lentil etc. Faba bean is grown as sole crop

Description of technology

Swarna Gaurav is a bushy type (77-105 cm), early duration (120-125 days), short bold grains (1,000 seed weight 281g), drought tolerant, moderately resistant to major insect pest and diseases. Length of pod is 4.0-4.5 cm, average productivity is 3.5 to 4.0t/ha and 2.0 to 2.2t/ha, under sole and intercropping system, respectively. Sweetness of the mature seeds is 10.34 TSS. Contents low of ant-nutritional factor tannin and phytate.

Applicability/ Situations: Irrigated ecology of Bihar Eastern UP and Jharkhand.

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Reducing alternate bearing in pistachio nut

High hills and valleys in dry temperate regions of Kinnaur (Pooh), cold deserts of Lahual and Spiti, along with some parts of district Chamba of Himachal Pradesh, and Leh and Kargil districts of Ladakh in Jammu and Kashmir are suitable for the cultivation of pistachio nut (*Pistacia vera* L.). The irregular yield caused by alternate bearing and low yield are among the major issues that are faced in pistachio cultivation. As a consequence of inadequate and unbalanced nutrition, the plant cannot develop satisfactorily and problems like low yield and insufficient nut quality are also observed. Low yields have been mainly attributed to factors such as periodicity, inadequate pollination, fertilization, prolonged periods of water stress due to low rainfall, and primitive traditional cultural practices such as planting, maintenance, fertilization and harvesting of pistachios trees.

NPK as a soil fertilizer to increase yields has been largely dependent on the soil type, as crops grown on soils with high K fixation show less response to applied NPK. Besides, the foliar application of boron (B) is more effective and economic than soil application in supplying nutrients to plant directly and quickly. The present research was accomplished on 8-year-old Kerman pistachio nut for four consecutive cropping periods. The male trees of cultivar Peter were maintained at 1:9 ratio (male: female) in the orchard.

Female flower of pistachio nut

Male flower of pistachio nut

Foliar B supplementation during late dormancy reduces blanking (emptiness) as well as non-spliting and

Flowering and fruiting behavior of pistachios affected by NPK and boron fertilization

Treatment	On Year				Off Year				
	Flower bud abscission (%)	Fruit set (%)	Fruit drop (%)	Fruit retention (%)	Flower bud abscission (%)	Fruit set (%)	Fruit drop (%)	Fruit retention (%)	ABI
N_{600} P_{600} K_{800}	23.7	71.5	6.7	64.2	24.9	64.7	3.7	58.0	0.112
Control	18.8	54.6	19.3	33.5	20.0	55.1	18.5	31.4	0.159

ABI, alternate bearing index

Pistachio nut orchard in Spiti valley, HP

Bearing branch of pistachio nut

Nut yield and nut filling characteristics at crop harvest in pistachios

Treatment	On Year					Off Year				
	Yield (kg tree^{-1})	Filled nut (%)	Split nut (%)	Empty nut (%)	Fruit sphericity (%)	Yield (kg tree^{-1})	Filled nut (%)	Split nut (%)	Empty nut (%)	Fruit sphericity (%)
N_{600} P_{600} K_{800}	9.4	81.0	74.9	16.8	70.92	7.5	73.9	77.9	17.1	71.23
Control	5.1	65.2	57.5	19.1	47.58	3.7	59.4	52.5	19.8	47.82

consequently increases nut yield of pistachio trees. Limited use of fertilization could be partially attributed to a scarce knowledge of nutrient requirement and lack of documented effects on improving nut yield and quality in pistachio nut on improving nut yield and quality. An understanding of the mechanisms responsible for alternate bearing in nut tree crops is important when critically evaluating the effects of boron and NPK fertilization besides, pruning and training strategies commonly used by growers to minimize alternate bearing. Weather conditions impact fruit set, flowering intensity, fruit retention and development can exacerbate the alternate bearing tendency of individual tree within the whole orchard.

Technological intervention

Application of N:P:K (600:600:800 g tree^{-1}, $N_{600}P_{600}K_{800}$) in the late dormant stage (December-January) along with foliar B (0.5% as boric acid) at four different stages namely, *(i)* the early bud break-flowering (mid April), *(ii)* the leafing out (fourth week of April), *(iii)* the full leaf out stage (May), and *(iv)* the fruit setting stage (last week of May) significantly increases fruit set, reduces buds abscission, blanking as well as non-splits and consequently, increases nut yield. The mode of N fertilization involved twice annually i.e. first split in the month of March (two-third), and the second split (one-third) in the month of April. Timing of foliar applications of boron is critical. Lightly cropping pistachio trees (off year) yielded 25.3% less compared to heavily cropping trees (on year). Until now, determination of the effect of N, P, K and B fertilization in mature pistachio trees has not been adequately studied in dry temperate region of India.

The present study is the first to quantify nutrient pools and their contribution to the current season's nutrient demand in mature and field-grown trees. NPK and foliar B application influenced vegetative growth measurements, the flowering and fruit set, reduced buds abscission, blank pistachios and improved nut quality traits during 'on' and 'off' year cropping season. Since pistachio tree is a very long-life species with a very deep root system, therefore, future research should focus for longer periods about physiology of the bud abscission, for alternate bearing behavior is needed to find a clearer physiological mechanism.

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New grass varieties released

Indian hot arid zone occupies an area of about 31.7 million hectares of which 62% lies in western Rajasthan. In this region, semi-starvation in livestock happens due to shortage of around 61% green and 17% dry fodder in normal rainfall years. In this situation, perennial grasses play significant role to ensure fodder availability. These grasses are mostly rhizomatous and remain dormant during adverse climatic conditions. The fodder of most of these grasses is free from anti-nutritional factors providing nutritive feed to the livestock at low cost, ameliorate soil health and reduce soil erosion process. Buffel grass (*Cenchrus ciliaris*) and sewan (*Lasiurus sindicus*) are the most dominating grass species in the hot arid region of thar desert of Western Rajasthan. Germplasm of these grass varieties were collected from different niches of the hot arid region and tested at Jodhpur and other regional stations. From this germplasm promising genotypes have been selected and released as varieties. These varieties have been released for Rajasthan state vide Gazette notification no. S.O. 1379 (E), Ministry of Agriculture and Farmers' Welfare, dated 27-03-2018.

Cenchrus ciliaris variety CAZRI Anjan 358

C. ciliaris variety CAZRI Anjan 358 (IC No. 296647) with high green and dry matter yield was collected from western Rajasthan during 1962. This variety produced 84.1q/ha green fodder yield and 20.0 q/ha dry matter yield which was 35.9% and 10.5% higher respectively than the yield of check variety (CAZRI 75). This variety produced 266 kg/ha seeds which was 179.1% more than the check CAZRI 75 (95.3 kg/ha) and 518.6% more than the check IGFRI 3108 (43.0 kg/ha). This variety attaining an average height of 106.4 cm is free from major diseases and insects.

Field view of variety CAZRI Anjan 358 and node pigmentation (specific character)

Cenchrus ciliaris variety CAZRI Anjan 2178

This variety of Anjan grass, having IC No. 198632, with high green and dry matter yield was collected during 1995 from western Rajasthan. This selection was tested in All-India Coordinated Research Project on Forage Crops trials during 2004 to 2006 along with two checks CAZRI 75 and IGFRI 3108. This variety yielded 108.4 q/ha green fodder yield and 38.4 q/ha dry matter yield which were 15 - 33% higher than the yield of two checks CAZRI 75 (94.1 q/ha) and IGFRI 3108 (81.2 q/ha) in green fodder yield and 82% more than IGFRI 3108 (21.1 q/ha) in dry matter yield. This variety produced 57.2 kg pure seeds per hectare which was 104% more than the check CAZRI 75 (28.0 kg/ha). Due to thin stem, the variety is most suitable for small ruminants. This variety contains 5.1% crude protein which is 59-76% more than the two checks CAZRI 75 (3.2%) and IGFRI 3108 (2.9%).

CAZRI Anjan 2178 – single plant

Inflorescence colour of variety CAZRI Anjan 2178

Lasiurus sindicus variety CAZRI Sewan 1

CAZRI Sewan 1 is a variety of Sewan grass with high forage yield suitable for arid and hyper hot arid regions. This variety developed through mutation breeding was tested in All-India Coordinated Research Project on Forage Crops trials during 2010 to 2013. Overall mean was considered to check the performance of this variety as there was no released variety

Inflorescences of proposed variety CAZRI Sewan 1

Single tussock and field view of variety CAZRI Sewan 1

during the time of establishment of the trial. This variety produced 156.8 q/ha green fodder yield and 57.1 q/ha dry matter yield. The green and dry matter productivity were 2.29 q/ha/day and 0.87 q/ha/day respectively. During 2014-2016, this variety produced 61.9 q/ha green forage and 25.69 q/ha dry matter yield which was 29.0% more than the general mean prevailing under Jodhpur conditions. On an average the plants attained a height of 111.5 cm. Its leaf: stem ratio was 1.43 exhibiting its leafiness and therefore, the variety is well relished by the cattle.

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Peach – A profitable fruit plant

The present study was initiated in 2008 for identifying most compatible intercrops with peach plants and to ascertain the effect of different moisture conservation practices on the growth performance and fruit yield of peach plants. One-year old grafted saplings of peach cultivar *Shan-E-Punjab* were procured from PAU and planted in a pit size of $1m^3$ dug out at 6m × 6m spacing during January 2008.

Managing peach tree

Peach orchard

Peach blossom

The intercrops viz. sorghum (*Sorghum bicolor L.*), pearl millet (*Pennisetum typhoides*) and cluster bean (*Cyamopsis tetragonaloba*) were sown in *kharif* season. The moisture conservation practices for peach plants include: (i) Control (flat basin), ii) Trench (1m*0.3m*0.3m, l*b*d), and (iii) Circular Trench (0.3m*0.3m, b*d, 50cm away from trunk). The study consisted of 12 treatments given below:

1. Pure Peach (control)
2. Peach + Trench
3. Peach + Circular Trench
4. Peach + Sorghum
5. Peach + Pearl Millet
6. Peach + Cluster Bean
7. Peach + Sorghum + Trench
8. Peach + Pearl Millet + Trench
9. Peach + Cluster Bean + Trench
10. Peach + Sorghum + Circular Trench
11. Peach + Pearl Millet + Circular Trench
12. Peach + Cluster Bean + Circular Trench

The results of the 9-year study indicated that average plant height (5.74 m), spread (7.92 m) and fruit yield (137 kg/plant) was obtained maximum in Peach + Guar + Circular Trench as compared to other treatments. Plant height ranged from 4.40 m to 5.74 m, spread from 5.90 m to 7.92 m and yield from 103.25 kg/plant to 137.0 kg/plant among various treatments. Peach + Circular Trench + Cluster Bean combination was found most effective in conserving the most precious natural resources viz; soil and water by producing minimum run off and sediment loss of 3.49% and 0.69 t/ha respectively. The Control/Pure plantation produced maximum run off of 10.32% and sediment loss of 2.12 t/ha. Among various treatments, B : C ratio ranged from 3.83 to 5.24, maximum in Peach + Cluster Bean + Circular Trench with a payback period of 6-7 years.

The first sample fruiting was obtained/harvested after 3rd year of plantation in 2010 and in a span of 8 years, peach plantation gave a gross revenue of ₹23.98 lakh and the productivity ranged from 4.43 t/ha – 38.10 t/ha (2010-17). Maximum gross revenue per plant was obtained at ₹2800 in the year 2016.

These findings can be implemented in the Shivaliks of Jammu, Himachal Pradesh, Punjab, Haryana and Uttarakhand experiencing sub-tropical climate and hilly areas of Punjab and Nilgiris. Due to high returns per unit area and low gestation period and availability of low chilling cultivars, there is a good scope for cultivation of peach in the North Indian subtropics and plains of Uttar Pradesh, Bihar and West Bengal which falls in Indo-Gangetic plains.

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Agroforestry Mapping in India using Geospatial Technologies: CAFRI's Methodologies

Geo-spatial technologies are now being widely used in agriculture, forestry, watershed, natural resource management. The integrated use of geo-spatial technologies like, Geographical Information System (GIS), Remote Sensing (RS) and Global Positioning System (GPS) have the potential to map the area for desired feature *e.g.*, agroforestry. In agroforestry, however, these technologies have yet to be used extensively.

In India the diagnostic survey and appraisal of agroforestry practices in the country revealed that there are enumerable practices in different agro-ecological zones. These systems/ practices occupy sizeable areas, but this area is yet to be accurately estimated. Though some estimates are available for agroforestry area in the country, all these estimates are not accurate estimates as they are not based on secondary data.

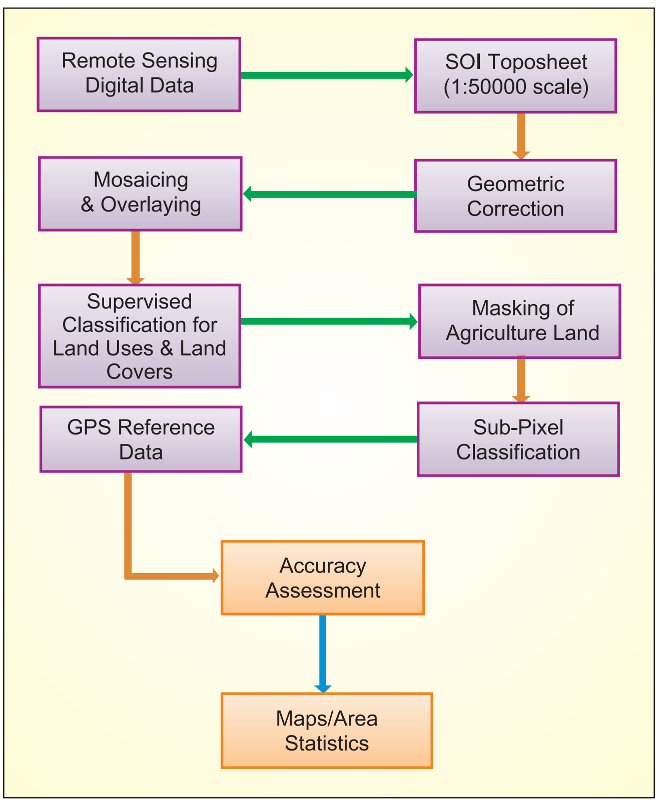
Agroforestry plays a significant role in climate change mitigation through carbon sequestration. To know the carbon sequestration potential, an accurate estimate of area under agroforestry systems in the country is essential. A major problem in estimating area under agroforestry is lack of procedures for delineating the area influenced by trees in a mixed stand of trees and crops. Methodologies have been developed and standardized by ICAR- Central Agroforestry Research Institute, Jhansi (UP) for different types of remote sensing data. One methodology is developed for medium resolution remote sensing data (eg. LISS-3) and other for high resolution remote sensing data (eg. LISS-4).

Methodology developed for agroforestry mapping

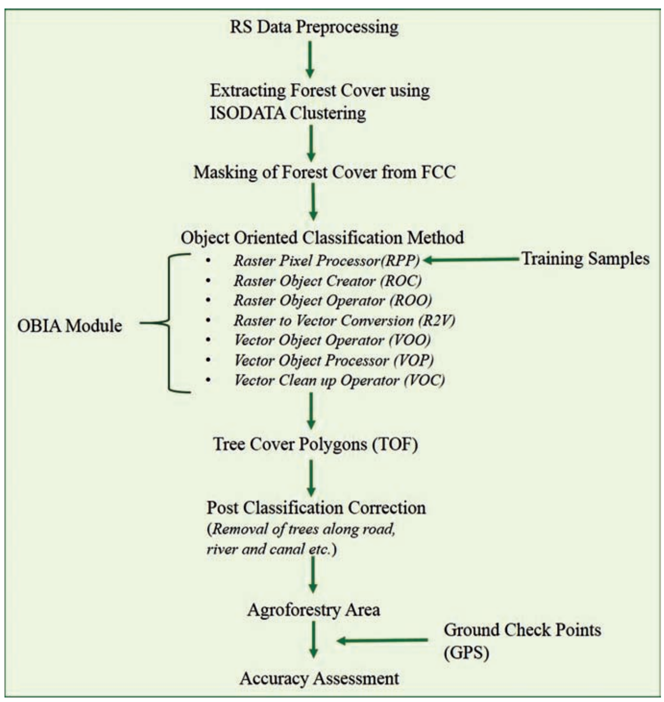
Medium Resolution Data

In case of medium resolution data, for mapping and estimating area under agroforestry in India, the following approach has been adopted:

- From each agro-climatic zone, 20% districts representing that zone will be randomly selected.
- For each district, remote sensing data (LISS III, 23.5 m resolution) will be analysed for land uses and



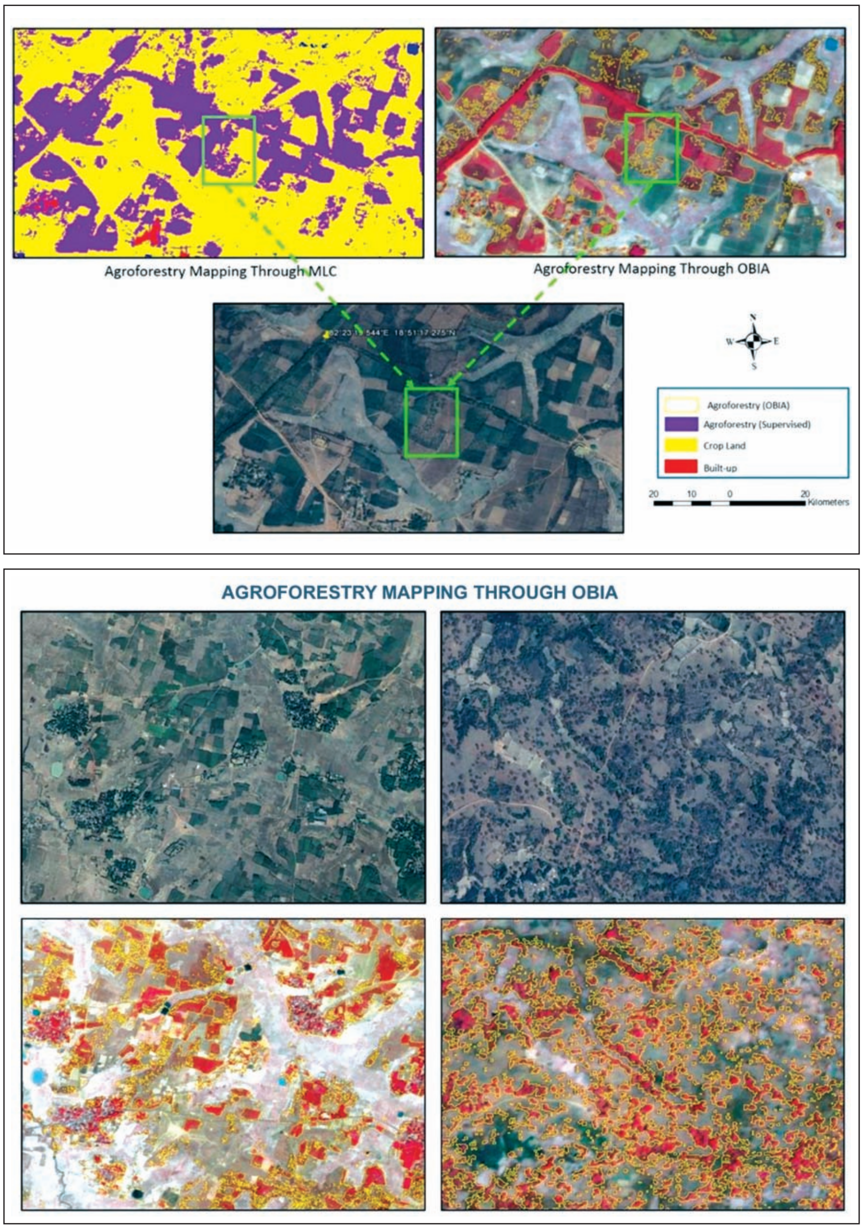
Methodology for mapping agroforestry area through sub-pixel classifier



Object based image analysis (OBIA) based methodology for agroforestry mapping land covers (LULC) using maximum likelihood classifier.

- From this LULC, agricultural land (cropland + fallowland) will be masked because agroforestry exists on agricultural land only.
- Then sub-pixel classifier method will be applied on this agricultural area, which gives output in the form of classes as per the tree cover (20-29, 30-39,.........., 90-100 %) within a pixel.
- Advantage of sub-pixel classifier is that all types of agroforestry (scattered trees on farmlands, boundary plantations and agri-silvicuture/ agri-horticulture and block plantations), are identified. This is not true in case of pixel based classifiers such as maximum likelihood, minimum distance to mean, etc.
- Agroforestry area obtained for such 20 % districts in a particular agro-climatic zone will be extrapolated for entire zone. Cumulative sum of area under agroforestry for all agro-climatic zones will give an estimate of area under agroforestry for the whole country.

The above methodology has been applied in selected districts of different agro-climatic regions and results with more than 80% accuracy were obtained. For mapping agroforestry on farmlands, sub-pixel method found better than pixel based method of classification when medium resolution data is used. Thus, proposed methodology based on sub-pixel classifier can be adopted for mapping agroforestry using medium resolution data.



Mapping of agroforestry by MLC (*top*) and OBIA (*top-right/bottom*) classification methods

High Resolution Data

In case of high resolution remote sensing data (LISS-4, spatial resolution - 5.8 m), pixel or sub-pixel based methods do not give much accurate results. So another methodology based on object oriented classification technique has been developed by CAFRI, Jhansi for mapping trees outside forest as well as agroforestry at district level. With this methodology very good and accurate results were obtained as compared to pixel based maximum likelihood classifier. Results of mapping trees outside forest and agroforestry in Sundargarh district of Odisha using this methodology is shown.

Present status of Agroforestry Area

Under the NICRA Project, area under agroforestry in different agro-climatic regions is being estimated using developed methodologies discussed above. So far 12 agro-climatic regions have been completed and area under agroforestry come out to be 23.25 million ha (8.69%) in these regions. By 2020 all the 15 agro-climatic regions will be completed providing final figure of agroforestry area in the country, which would be useful for agro foresters and policy makers.

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Zero Budget Natural Farming for Management of Invasive leafminer (*Tuta absoluta*) in tomato

Tuta absoluta (Meyrick) native to South America, is one of the most destructive insect pests of tomato. The pest is capable of causing 100 % crop damage in the absence of appropriate control measures. Outside South America, this pest was detected for the first time in Spain during 2006. Since then, it has rapidly invaded 79 countries. In India, the incidence of this pest was recorded for the first time on tomato in Pune and Bengaluru during 2014, and now has spread to almost all tomato growing areas of the country. In Himachal Pradesh, *T. absoluta* was detected for the first time in 2015 on tomato at Nauni in district Solan. This pest has now emerged as a serious threat to tomato in the state both in open fields and polyhouses.

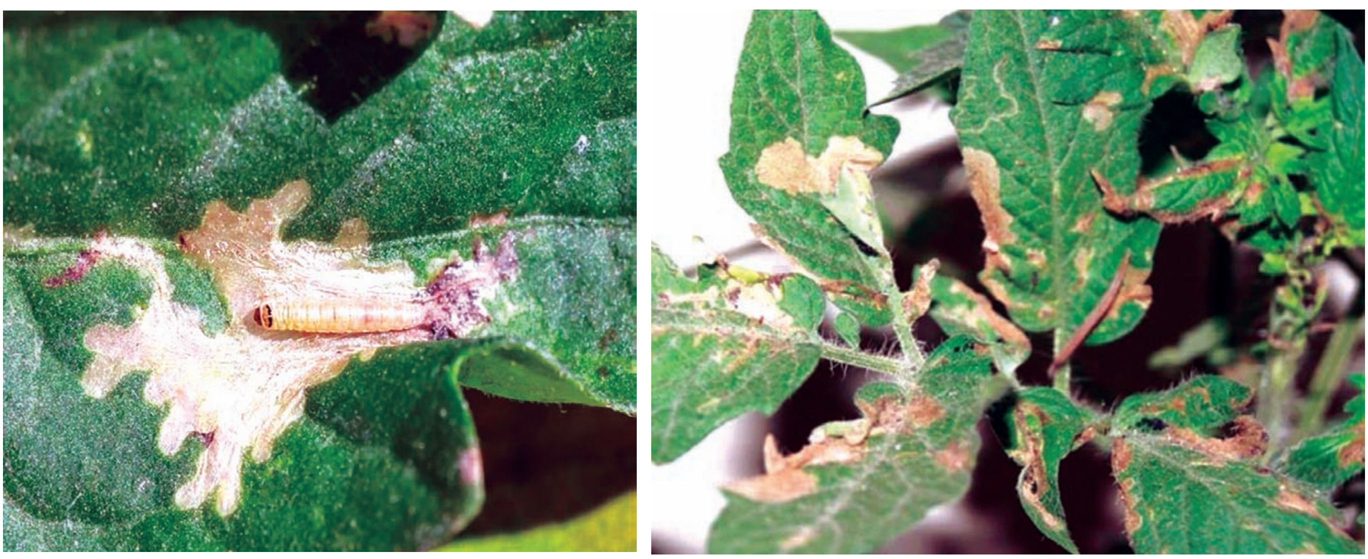
A survey was conducted to record the incidence of *T. absoluta* during 2017 and 2018 at 17 locations of districts Solan, Sirmour, Shimla, Kinnaur and Bilaspur, which are the major tomato growing areas of Himachal Pradesh. The incidence of the pest was also recorded under polyhouse conditions at Nauni of district Solan on tomato and brinjal. Under open field conditions, the pest infested tomato at 12 locations (Table 1). At these locations 11 to 83 % of the tomato plants were infested with *T. absoluta* with the number of mines/leaf/infested plant varying from 1-7 and fruit damage from 0-7% at different locations. Under polyhouse conditions, severity of the pest was more on tomato than on brinjal.

In tomato, 100 % infestation was recorded under no control measures conditions. In brinjal, however the incidence was very low. Survey revealed more pest severity under polyhouse cultivation than in open field conditions and more preference to tomato over other host plants.

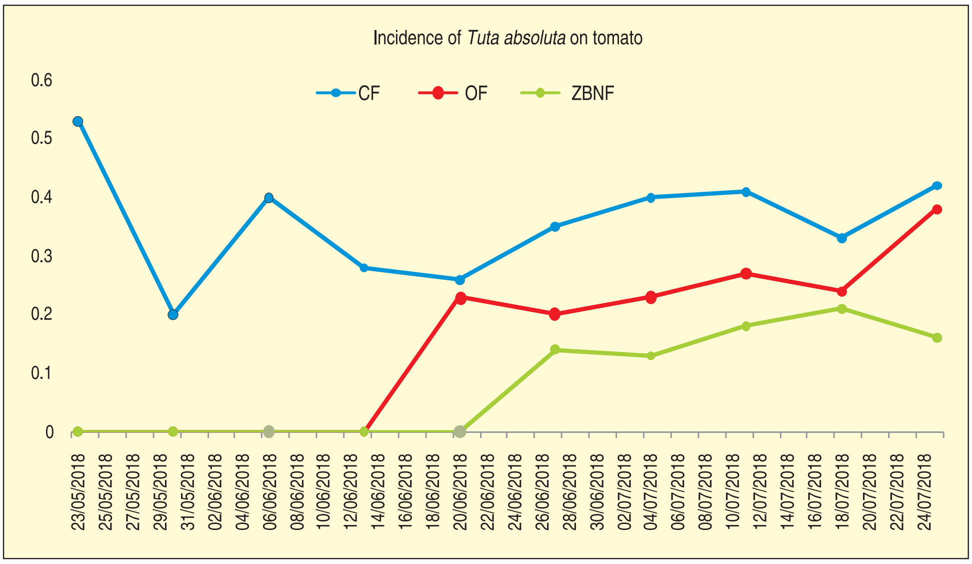
Infestation of *Tuta absoluta* on tomato under open field conditions at different locations

Location	District	Plants infested (%)	Mines/ leaf/ infested plant	Fruit damage (%)
Nauni	Solan	43-79	1-7	0-5
Dolanji	Solan	40-72	2-5	1-3
Dharja	Solan	38-61	2-6	0-3
Maryog	Sirmaur	11-33	1-3	0-2
Nainatikkar	Sirmaur	51-67	2-5	1-5
Deothi	Solan	12-21	1-2	0-2
Subathu	Solan	46-59	2-5	0-5
Sarahan	Sirmaur	60-76	1-7	0-3
Kandraur	Bilaspur	Nil	Nil	Nil
Rampur	Shimla	Nil	Nil	Nil
Bagthan	Sirmaur	67-83	2-6	2-5
Sanaura	Sirmaur	64-78	2-6	1-7
Mandi	Mandi	38-74	0-6	1-5
Kullu	Kullu	42-69	1-4	0-5
Kalpa	Kinnaur	Nil	Nil	Nil
Nichar	Kinnaur	Nil	Nil	Nil
Urni	Kinnaur	Nil	Nil	Nil

Zero Budget Natural Farming (ZBNF) is a set of farming methods and is a grass root peasant movement, which



Tuta absoluta larva and infested tomato leaf



has spread to various states in India. It has attained wide success in southern Indian states of Karnataka and Andhra Pradesh, where it was evolved and implemented by Padamshree Shri Subhash Palekar. The main aim of ZBNF is to eliminate chemical pesticides and promote good agronomic practices. ZBNF promises to end a reliance on loans and drastic cut on production costs, ending the debt cycle for desperate farmers. NITI Aayog in its recent Vision Document has taken ZBNF as a potential technology capable of providing notable increases in farmers' net income by sharply reducing costs of production to negligible and improving incomes by raising yield and quality of agricultural produce.

Tomato crop was grown under different farming systems i.e. zero-budget natural, organic and conventional farming systems. The experiment was conducted at the experimental farms of Dr YSP University of Horticulture and Forestry, Nauni, Solan (HP). Each farming system was separated from the other by about 500 m distance. In each case, the tomato (cv. Solan Lalima) crop was transplanted between 21 and 23 April 2018. Incidence of *Tuta absoluta* was recorded on tomato under all systems at weekly intervals starting from 23 May until 25 July on leaves and 6 August on fruits.

Results revealed that the incidence of *Tuta absoluta* was significantly less in Zero budget natural farming (ZBNF) system as compared to the organic farming (OF) and conventional farming (CF). Interestingly *T. absoluta* appeared on ZBNF plots 4 weeks later than the conventional plots received regular pesticide applications of chlorantraniliprole (0.5ml/L) on 26 May, 8 June and 12 July 2018, whereas, organic farming plots were treated with neem kavch (2ml/L) four times on 21 June, 28 June, 3 July and 10 July 2018. In ZBNF, Darekastra and Bramhastra prepared from the locally available plants, indigenous cow urine and dung were applied alternatively at weekly interval. In the present study, this farming system appears to be effective in tomato cultivation. Large scale adoption of this farming will definitely increase the net income of the farmers and will be very helpful to double the farmers' income.

Tomato crop infested with of *Tuta absoluta* under polyhouse condition

Tomato crop under Zero Budget Natural Farming

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PROFILE

ICAR-National Institute of Agricultural Economics and Policy Research

Acting as think tank of ICAR and helping the Council to actively participate in policy making

ICAR-National Institute (formerly Centre) of Agricultural Economics and Policy Research (NIAP) was established by the Indian Council of Agricultural Research (ICAR) in March 1991 to strengthen agricultural economics and policy research in the national agricultural research system. Application of principles of economics in planning and evaluation of agricultural R and D and policy research to promote science-led agricultural and rural development have been the main goals of ICAR-NIAP. The Institute is committed to provide a leadership role in strengthening agricultural policy research, undertaking empirically sound policy research, and providing knowledge-based input for policy decisions. The Institute also acts as a think tank of ICAR and helps the Council to actively participate in policy making.

VISION

Leveraging innovations for attaining efficient, inclusive and eco-friendly agricultural development through agricultural economics and policy research.

MANDATE

To conduct policy-oriented research in network mode on:

- Technology generation, diffusion and impact
- Sustainable agricultural production systems
- Interaction between technology and other policy instruments like incentives, investments, institutions and trade and
- Agricultural growth and development with focus on the role of technology

To strengthen capacity in agricultural economics and policy research in the National Agricultural Research System (NARS)

To enhance the participation of ICAR in agricultural policy decisions through policy-oriented research and professional interactions

To accomplish its vision and mandate, NIAP follows a

Policy Papers

- ***Understanding the Recurring Onion Price Shocks.*** Raka Saxena, Ramesh Chand. NIAP Policy Paper No.33 (2017).
- ***Mainstreaming Climate Change Adaptation into Development Planning.*** Naveen P Singh, Arathy Ashok, Pavithra S, Balaji S J, Bhawna Anand, Mohd Arshad Khan. NIAP Policy Paper No.32 (2017)
- ***Strategy for Doubling Income of Farmers in India***. Raka Saxena, Naveen P Singh, Balaji S J, Usha R Ahuja, Deepika Joshi. NIAP Policy Paper No.31 (2017)
- ***Enhancing Farmers' Income: Who to Target and How?.*** Pratap S. Birthal, Digvijay S. Negi, Devesh Roy. NIAP Policy Paper No.30 (2017)
- ***The Impact of Information on Returns from Farming.*** Pratap S. Birthal, Shiv Kumar, Digvijay S. Negi, Devesh Roy. NIAP Policy Paper No.39 (2015)
- ***Commodity outlook on major cereals in India.*** Shinoj Parappurathu, Anjani Kumar, Shiv Kumar and Rajni Jain. NIAP Policy Paper No.28 (2014)
- ***Biofuel in India: Potential, Policy and Emerging Paradigms***. Raju, S. S., Shinoj Parappurathu, Ramesh, Chand, P. K., Joshi, Praduman, Kumar and Siwa, Msangi. NIAP Policy Paper No. 27 (2012)
- ***Instability and Regional Variation in Indian Agriculture.*** Chand, Ramesh and Raju, S. S. NIAP Policy Paper No.26 (2011)
- ***Total Factor Prdoductivity & Contribution of Research Investment to Agricultural Growth in India.*** NCAP. Chand, Ramesh, Praduman Kumar and Sant Kumar. NIAP Policy Paper No. 25 (2011)
- ***India's Livestock Sector Trade: Opportunities and Challenges***. Kumar, Anjani. NIAP Policy Paper No.24 (2009).
- ***Research Resource Allocation in Indian Agriculture.*** Dayanatha Jha and Sant Kumar. NIAP Policy Paper No.23 (2006)
- ***Changing Pattern of Rice Production Systems and Technology in Assam***. B. C. Bhowmick, B. C. Barah, Sushil Pandey, and N. Barthakur. NIAP Policy Paper No. 22 (2005).
- ***Demand and Supply Projections for Livestock Products in India.*** M. B. Dastagiri. NIAP Policy Paper No.21 (2004)
- ***Agricultural Research Priorities for South Asia.*** Mruthyunjaya, Pal Suresh and Saxena Raka . NIAP Policy Paper No.20 (2003)
- ***Government Intervention in Foodgrain Markets in the New Context***. Chand, Ramesh. NIAP Policy Paper No.19 (2003)
- ***Economic Potential of Biological Substitutes for Agrochemical***. Birthal, P. S. NIAP Policy Paper No. 18 (2003)
- ***Agricultural-based Interventions for Sustainable Nutritional Security***. Adhiguru, P. and C. Ramasamy. NIAP Policy Paper No.17 (2003)
- ***The funding and organization of agricultural research in India: evolution and emerging policy issues***. Pal, Suresh and Derek Byerlee. NIAP Policy Paper No. 16 (2003)
- ***Assessment of Research Priorities for Livestock Sector India.*** Birthal, P.S., Joshi, P.K. and Anjani Kumar. NIAP Policy Paper No. 15 (2002)
- ***Irrigation Development and Equity Impacts in India***. Selvarajan, S., A. Ravishankar and P.A. Lakshmi Prasanna. NIAP Policy Paper No.1 4 (2001)
- ***Impact of Tenancy Reform on Productivity Improvement and Socio-Economic Status of Poor Tenants.*** Haque, T. NIAP Policy Paper No. 13 (2001)
- ***Public-Private Interface and Information Flow in the Rice Seed System of Andhra Pradesh (India).*** Pal, Suresh, Robert Tripp and A. Janaiah. NIAP Policy Paper No. 12 (2000)
- ***Emerging Trends and Regional Variations in Agricultural Investments and their Implications for Growth and Equity***. Chand, Ramesh. NIAP Policy Paper No. 11 (2000)
- ***Privatizing Agricultural Extension in India***. Sulaiman V., R. and V. V. Sadamate. NIAP Policy Paper No.10 (2000).
- ***Sources of Growth in the Livestock Sector***. Birthal, P.S., Anjani Kumar, A. Ravishankar and U.K. Pandey. NIAP Policy Paper No. 9 (1999)
- ***Improving the Effectiveness of Agricultural Research and Extension in India: An Analysis of Institutional and Socio-Economic Issues in Rainfed Areas***. Farrington, J., Rasheed Sulaiman V. and Suresh Pal. NIAP Policy Paper No.8(1998)
- ***Agricultural Research and Extension in India: Institutional Structure and Investments.*** Pal, Suresh and Alka Singh. NIAP Policy Paper No. 7 (1997),
- ***Import Liberalization and Indian Agriculture: The Challenge and Strategy.*** Chand, Ramesh. NIAP Policy Paper No.6 (1997),
- ***Small Farms, Employment and Surplus Generation- A Case of West Bengal.*** Maji, C. C. and T. Haque and A. Bhattacharya. NIAP Policy Paper No. 5 (1995)
- ***GATT and Agricultural Exports- Hopes and Realities.*** Maji, C. C. and A. Bhattacharya. NIAP Policy Paper No.4 (1995)
- ***Research Priorities in Indian Agriculture.*** Jha, D., P. Kumar, Mruthyunjaya, Suresh Pal, S, Selvarajan and Alka Singh. NIAP Policy Paper No. 3 (1995),
- ***Production prospects and Constraints to Higher productivity of Pulses in Madhya Pradesh.*** S. P. Pant. NIAP Policy Paper No. 2 (1995)
- ***Impact of Tenancy Reform on Production and Income Distribution – A Case Study of Operation Barga in West Bengal.*** Sasanka S. Pal. NIAP Policy Paper No. 1 (1995)

three-pronged strategy encompassing (i) strong policy research in network mode with (a) NARS (b) mainstream economics research institutes; and (c) international organizations (ii) capacity strengthening programs in agricultural economics, policy analysis and policy communication and (iii) interface with policy makers through effective policy communication.

Research Activities

The research activities of the Institute are organized under three Divisions, viz. (i) Technology and Sustainable Agriculture (ii) Markets, Trade and Institutions and

(iii) Agricultural Growth and Development.

Technology and Sustainable Agriculture

This Division deals with research and development (R and D) policies, innovative institutions and policies fostering sustainable agricultural development. Research under this theme provides future R and D policy to meet the emerging challenges. This theme also focuses on improving resource use efficiency, saving and conserving natural resources and rehabilitation of degraded natural resources.

Markets, Trade and Institutions

The focus of this Division is on issues related to market reforms, international trade, prices, distribution and value addition. Innovative institutions in the supply chain, input markets, and delivery of farm services are also covered. The key issue is to evolve mechanisms so that smallholders' share in emerging opportunities is maximum in the entire value chain.

Agricultural Growth and Development

Agricultural growth is driven by technologies, policies, incentive structures, investment and resource endowments. Agricultural growth and development needs to be studied in the long-run perspective emphasizing farm and non-farm linkages, structural changes in agriculture and other adjustment processes. Research areas under this theme include future sources of growth, risk in agriculture, agricultural diversification, investment and subsidy in agriculture, investment priorities, and role of infrastructure in poverty alleviation.

Significant Achievements

Technology policy: India spends only 0.4% of its agricultural gross domestic product on agricultural research, much lower than in the developed countries. There is sufficient evidence to show that the payoff from investment in agricultural R and D is very attractive. Higher investment in agricultural research is required to keep yield frontiers upward, to reduce cost of production and to break yield barriers in several crops. The study on total factor productivity (TFP) for major crops indicates that the highest growth in TFP has been reported for wheat and maize (1.6 %) for the period 1996-2005. Share of TFP in the output growth was 60 % in wheat and 30 % in maize. The growth in TFP for crop sector accelerated during the period 2002-12, and almost entire growth in the output was attributed to the growth in TFP.

Irrigation: Equity in the use of surface water has improved over time in most of the states. Donor driven institutional initiatives cannot be sustained for management of water resources. Streamlining of accounting procedure to link cost recovery and O and M funding is essential. Irrigation department should be empowered to identify water user categories, enforce water supply measurement and charge the bulk users.

Although physical performance of irrigation projects showed a substantial growth during successive five year plans, it co-exists with increasing gap between irrigation potential created and utilized. Improving utilization of already created irrigation infrastructure by removing existing operational and maintenance inefficiencies will contribute positively to agricultural growth. There is a need to switch from traditional (furrow, border and flood irrigation) to modern irrigation technologies (drip, sprinklers), along with institutional and policy support for improving irrigation efficiency.

Unsustainable groundwater development is the outcome of inter-regional disparities, provision of subsidized electricity and pumps and excessive private investment in groundwater without considering suitable recharge mechanisms. Efficient groundwater governance by regulating excessive withdrawal (in over-exploited regions) and promoting its utilization (in less developed eastern region) through effective legislation and policy intervention, is of prime importance for sustainable growth.

Diversification and poverty: Diversification of agriculture towards high-value enterprises such as horticulture and animal husbandry that generate higher returns matches with resource endowments and income requirements of smallholder farmers who allocate larger area to high-value crops and are also more efficient in their production, compared to larger farmers. The incidence of poverty is less among those engaged in these enterprises, the biggest impact being on marginal and small farmers. Thus, diversification, supported by technology, markets and policies can be an important

pathway to enhance farmers' income, create employment opportunities, sustain agricultural growth and reduce poverty.

Reforming markets: Price policy and market reforms should (i) enhance competition in the marketplace by linking farmers to markets through institutional innovations such as contract farming and producer associations; (ii) promote investment in public infrastructure (roads, electricity, and communication) that reduces transportation and transaction costs, (iii) induce the private sector to invest in agro-processing, cold storage facilities, refrigerated transportation, and retail chains to enhance efficiency of the value chains and minimize post-harvest losses and (iv) improve farmers' access to credit, inputs, information and services.

Food demand: By 2050 availability of resources for agriculture will increase but at a slower rate as compared to the growth in food demand. This underlines importance of improving resource use efficiency and technological breakthroughs. In order to strike a balance between the future demand and supply of agricultural products, the Institute has suggested to target a) significant increase in land productivity, b) twofold increase in water productivity, c) doubling energy use efficiency, and d) five times increase in labour productivity by 2050.

Trade: In order to benefit from globalisation, emphasis on food safety measures and compliance with various SPS measures are essential. This is essential to harness the untapped potential of dairy product exports to developed countries like USA, EU and Japan. The cost of compliance, investment required, handling and processing, and traceability of the products were identified as important issues that need attention for enhancing livestock exports.

Livestock policy: Livestock sector despite its considerable potential to enhance and sustain agricultural growth has remained underinvested and neglected by financial institutions (credit and insurance) and support services. The sector currently receives hardly 10% of the public spending and 5% of credit to agricultural sector. Further, our estimates of feed demand would help in reorienting food management policy and also towards optimization of livestock population. The estimates of the positive contribution of livestock to environment justify more resources for livestock development.

Land reforms: Tenancy laws of various states should be suitably amended keeping in view the region-specific needs. As far as possible, leasing-in of land only by small and marginal farmers should be allowed, while large farmers should be encouraged to take up non-farm enterprises.

Labour market: There are profound changes with labour moving from agriculture towards non-farm sectors. The diversification of the rural labour market is influenced by a set of factors such as the pattern of economic growth, inter-sectoral wage rate and labour productivity differentials, education, rural employment schemes and socio-cultural factors. Employment diversification has led to narrowing of large variations in real wages across different sectors in the rural economy. Increase in wage rate increases the cost of production and prices, and therefore, farm mechanization and custom hiring arrangements for small farmers should be promoted.

Future Thrust Areas

To realize the vision of 'leveraging innovations and policy for agricultural development,' the Institute focuses on the following key areas.

Technology and Sustainable Agriculture: The Institute will concentrate its research primarily on climate change, natural resource management and environment, risk in agriculture, valuation of environmental services, agro-climatic zonal planning and resource use efficiency, impact of agricultural technology, and performance evaluation of agricultural extension system.

Agricultural Growth and Development: Agricultural growth being the outcome of an inter-play of technologies, institutions and policies, NIAP research portfolio will comprise structural transformation of agriculture (income and employment) and disparities in development, agricultural diversification and drivers of growth, farm and non-farm linkages for enhancing farmers' income, property rights, gender, and agriculture-nutrition-health linkages. The Institute will continue to undertake studies on short-term and medium-term outlook for agriculture.

Markets, Trade and Institutions: The thrust will be on policy studies on market reforms, infrastructure development, marketing efficiency, commodity outlook, price forecasts, price transmission, mapping value chains and price policy for perishables, food industry, food quality and food safety, agricultural trade pattern, and international agreements. Innovations in input markets, credit and farm services shall also be studied.

Capacity Building: NIAP will continue to play a key role in strengthening capacity and human resource development in the field of agricultural economics and policy research. It will also forge linkages with advanced research institutions in India and abroad for capacity strengthening of its own faculty. Association with PG program of IARI and curriculum improvement shall be other capacity development activities of the Institute.

Partners

NIAP maintains close linkages with national and international organizations involved in agricultural research, development and policy analysis. Collaborative research projects, seminars, workshops, publications and participations in policymaking bodies are the usual modes of policy interface which help in improving the outreach activities of NIAP. Key partners of the Institute are listed below:

National

- IASRI, IARI, NAARM and other ICAR institutes and State Agricultural Universities
- ISEC, CESS, ISI, IGIDR, IIM-A, ICRIER, NAFED, NFDB, NISTADS
- NITI Aayog, Ministry of Agriculture and Farmers' Welfare, NABARD, Ministry of Food, Ministry of Environment and Forest and Climate Change
- NAAS, MSSRF, TAAS

International

- CGIAR Centres : ICRISAT, ILRI, IFPRI, ICRAF, CIMMYT, ICARDA, IRRI, IWMI
- UN Organizations: FAO, UN-CAPSA
- The World Bank, SAARC Agriculture Centre, BRICS
- ODI, Universities in developed countries

Corporate and agri-business sector

- YES BANK, BAIF
- Agriculture Insurance Corporation, SFAC.

Publications

NIAP regularly brings out publications like Policy Papers, Policy Briefs and Conference Proceedings. These serve as the main agents for dissemination of its research findings. During a short span of its existence, the Institute has established a track record of impressive research studies. So far, 392 research papers, 29 Policy Papers and 41 Policy Briefs are published.

Infrastructural Facilities

Library: NIAP library has a specialized collection, comprising of 3434 reference books, 125 CD-ROMs, 2321 database publications, 812 reports and 124 SAARC publications and other reference material. Presently, Institute has subscription of 15 international and 10 national journals and importantelectronic databases.

Agricultural Knowledge Management Unit: The AKMU is well equipped with latest computers, servers, firewall (Fortigate 80c) and analytical software like SPSS 23, STATA 12, LIMDEP 9.0, GAMS, Stella and SAS 9.3. A dedicated leased line of 100 MBPS is being supported by National Knowledge Network. All employees of the Institute have been provided with latest hardware, software, local area network and internet facilities. Further, E-governance initiative like ICAR MIS-FMS has been implemented in the Institute.

NIAP Website: NIAP website (http:// www.ncap.res.in) provides latest information about activities of the Institute, particularly collaborations, its staff, infrastructure, research projects, publications and procurement. The website is being accessed worldwide and its outreach is increasing to more countries.

Recognition

The Institute is recognized for its significant contributions and the scientists are recognized by the national and international organizations. National Professorships, Rafi Ahmed Kidwai Award, Fulbright Fellowship, and Borlaug International Science Fellowship are the notable awards and recognitions received by the scientists. Many scientists are members of the editorial boards and executive committees of professional journals and societies. Seven scientists of the Institute were awarded the Fellowship of the National Academy of Agricultural Sciences. NIAP as a team was recognized by national and international organizations. ICRISAT included NIAP in its Millennium Science Award 2007 as an Outstanding Partner for the excellent contribution in strategic partnership for demonstrating high quality science and innovations in social science research.

ISO 9001:2008 Certification

The Institute is regularly assessed for ISO 9001:2008 certification. Following the successful assessments for ISO certification, British Standard Institute (BSI) has awarded ISO 9001:2008 certificate bearing number FS 615169 to NIAP.

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Energy Innovations in Kargil

Technological interventions in the Zanskar valley are lacking and most of the tribal population lives on traditional and subsistence agriculture and livestock rearing. KVK is demonstrating scientific technologies for improving the livelihood of farming community in participatory mode. KVK under the aegis of SKUSAT, Kashmir took lead to provide innovative solutions at the household level to meet domestic needs of energy for water and room heating during winter.

Zanskar is among one of the cold arid inhabited highlands of the world, lying within an altitudinal range of 3,500 m to 6,478 m above mean sea level. It is the remotest and the least accessible part of Kashmir region where temperature ranges from –30˚C to 28˚C. To encounter the harsh winter, dung is the only source of energy in rural houses for cooking, water and space heating. Women toil hard to collect dung from grazing land and livestock sheds and store dung cakes for use during winter. LPG and electricity are not helpful due to freezing temperature of -30^{o}C during peak winter from December-February and dung cake is the only source of energy in villages of picturesque valley.

Plan, Implementation and Testing

Sunshine in this region is quite intense and clear for around 300 days and can be one of the major source of energy to meet domestic needs of the community. Though the Government has installed solar stations to provide electricity in villages but this supply is mainly for lighting purposes. Other needs of cooking, space and water heating are met solely through animal dung.

Solar water heating systems of evacuation tube model have been installed by affluent families but are not successful as tube cracking in winter is quite common and difficult to repair. Burning of dung in households produce lot of smoke affecting human health in the long run. Further, burning of dung deprives agriculture land of manure thus depleting soil fertility.

Efforts were made by KVK, Zanskar with the technical backstopping of SKUAST, Kashmir to design innovative panels from locally available material for water and space heating suitable for tribal community of Zanskar Valley of Ladakh region. Solar panels are fabricated on wooden frame available in local households. Other material used in this is, galvanized iron (GI) sheet as absorber and Galvanized Iron (GI) Pipe/ Aluminum alloy coil (3.75- 4.0 cm internal diameter) with inlet and outlet connection for water on two ends. Absorber GI sheet is fixed in the centre of wood frame. Backside of the absorber sheet is insulated with thermocol sheet (3.75 cm) glued with bitumen and covered on outer side with thin aluminum sheet for protection. On the front illuminated side of the absorber sheet is fixed with GI or aluminum water coil with reducers (2.5 cm) to outlet and inlet of water protruding through the wood frame for cold water and hot water connections. Absorber sheet and aluminum water coil is coated with black paint having fine carbon powder produced locally from specific wood which increased efficiency of solar energy absorption. At the top of coil panel, it is covered with two layers of window glass (4 mm) having 1.25 cm distance to hold air for insulation. Panel is installed at 45^{o} angel on the roof top facing south to capture maximum sunlight.

Demonstration of technology among the tribal farmers

Panel coil holds 18.0 liters of water and is heated to 70-80^{o}C within 30-45 min of solar illumination. Household members can draw 100-120 liters of hot water on a

Testing of Solar Water and Heating Panel in household

Distribution of Solar Panel among tribal community

clear sunny day for household purposes without burning fire place for water heating. These conditions promote efficiency of this system to maximum and replacement of GI pipe coil design with aluminum tube coil improves quality of hot water and is of potable quality and can also be used for cooking. Specially designed cold water inlet with antifreeze and silt drainage outlet was fitted for better efficiency with manual filling during winter when water supply from pipes is not available.

Solar space heating panel is same as that of solar water heating panel without water coil. The panel is fixed on south facing wall of the living room with air went at the lower and upper end. When black absorber sheet of the panel is heated with sun through glazing air between glazing and absorber sheet is heated and moves up and enter through upper went in living space. Vacuum is created between glazing and absorber space and cold air enter here from room. This way air siphon is created and the room air is heated to a comfortable level without any active use of energy. Therefore this panel is also known as Thermosyphoning Air Heating Panel (TAP). Testing of this technology revealed that low cost solar panels heated 120 liters of cold water (11^{0}C) into boiled water (84^{0}C) in 35 minutes.

Availability of hot water and heated space will reduce indoor pollution and hygiene of tribal people through regular bathing and washing of cloths. This will also save precious time of tribal women in collecting dung from field.

These innovative solar panels made of locally available material are cost effective with least post installation maintenance and can easily be fabricated by local artisans (carpenters). Local artisans have been trained by KVK to fabricate and install solar panels in villages and repair them if need arises.

Impact

After successful testing of technology, KVK, Zanskar piloted this project at few places in the valley and found feasible with good results. Tribal people are also very happy to use this technology. These innovative low cost solar heaters have been installed at 158 houses by arranging funds from Science for Equity Empowerment and Development Division (SEED), Department of Science and Technology (DST), Government of India. Ladakh Development Council (LDC) of District Kargil has also come forward to replicate this technology on large scale. Design, development and demonstration of the technology of solar water and space heating by KVK, Zanskar will go a long way in demonstration of this technology not only in Zanskar valley but also in other parts of Alpine region of Kashmir.

ICAR-ATARI

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WAY FORWARD

CASHEW (*Anacardium occidentale* L.) is a neglected crop species and was considered earlier only for wasteland development and soil conservation purposes. However, now, it has become one of the most important commercial horticultural crops of the country. The crop has three major produces, viz. cashew nut, cashew apple and Cashew Nut Shell Liquid (CNSL) besides several other minor uses such as medicinal use and production of tannins, briquettes etc. The cashew kernel is rich in nutrients in addition to nutraceutical components. The cashew apple is rich in minerals and vitamin C and is used in production of several value added products such as RTS, Feni, jam, jelly, cider (low alcoholic beverage) etc. The CNSL has several industrial applications such as use in paints and varnishes and as lubricant in break liners. This also has several reported medicinal properties. In recent years, farmers are realizing its potential due to the efforts of ICAR-Directorate of Cashew Research, the nodal center for cashew research in the country with 14 centers under AICRP on Cashew, spread across different states.

Presently, cashew is grown on 10.83 lakh ha in this country with a production of 8.17 lakh tonnes of raw cashew nut and with a productivity of 753 kg/ha (2017-18, DCCD, Kochi). India is the highest producer, processor and consumer of cashew in the world and 2nd largest exporter of the cashew kernel during the year 2016-17. As per export-import statistics published by the DGCI and S, Kolkatta, the share of agricultural products in the total export earnings of the country during 2017-18 (April 2017 to March 2018) is 6.65%, and cashew kernels ranked 6th among them, contributing 4.39% of the agri product exports. This accounts to 0.30% of the total foreign exchange earnings of the country through exports. As per the DGCI and S figures, the total export of cashew kernels from India during 2017-18 was 84,352 MT valued at ₹ 5,870.97 crore (US $ 911 Mln). There has been an increase of 2.5% in quantity, 14% in terms of rupees and 18% in terms of US $ as compared to the previous year (2016-2017). The export of CNSL/ Cardanol from India during 2017-2018 was estimated at 8,325 MT valued at ₹ 33 crore (US $ 5 Mln.).

India has built in capacity of cashew nut processing of approximately 27-28 lakh tonnes with more than 4,500 cashew processing factories. More than one million people particularly women labourers are employed in processing sectors. The remaining 8-9 lakh tonnes of nuts required for the processing factories are imported from African and some Asian countries. The total raw cashew nuts imported into India during 2017-2018 was 649,050 MT valued at ₹ 8,850.03 crore against the import of 770,446 MT valued at ₹ 8,839.42 crore achieved during 2016-17. As per the DGCIandS, the unit value of import price for raw cashewnut was ₹ 136.35/ kg during 2017-18 as against ₹ 114.73/kg during the previous year 2016-17. The major sources of raw cashew nut import were Ivory Coast, Tanzania, Guinea Bissau, Benin, Ghana, Mozambique, Nigeria, Senegal, etc. However, this import of nuts is going to be reduced in due course of time owing to the

Dr T Mohapatra, Secretary (DARE) and Director General (ICAR)

competition from other cashew processing countries and the development of recent processing facilities set up in these countries. Further, the domestic consumption of cashew kernel has increased up to 75-80% presently from 20-25% in nineties which has brought down the export of cashew kernels in the recent years. As per rough estimate, by 2030, the requirement of raw nuts in the country may be around 30 lakh tonnes. Under such a scenario, the country has a lot of scope for improving the production, employment generation, and export earnings.

It has been estimated that the requirement of raw cashew nuts will be 25.0 lakh tonnes by 2030, and would touch the mark of 45.0 lakh tonnes of raw cashew nuts by 2050. This target can be achieved by enhancing productivity of cashew to 2.5-3.0 t ha^{-1} by harnessing the power of science as well as area expansion in prospective locations. The low yielding cashew plantations of senile and non-descript origin need to be replaced with cashew grafts of high yielding varieties along with adoption of improved production technologies. ICAR's Directorate of Cashew Research (earlier known as NRCC) has developed improved cultivation package and developed several varieties/hybrids, which have potential for higher yield with quality. The Directorate was successful in convincing cashew farmers and corporations that the crop is highly package responsive and management of the plantation is must for getting higher yields. The 3-4 fold yield performance and profits could be demonstrated in several farmers' plots. The Directorate has taken up the challenge of producing 20–25 lakh cashew grafts annually for catering farmers demand and rejuvenation of old and senile orchards thereby achieving the required target of 25-30 lakh tonnes in next five to ten years. By bridging the gap between research and extension in this particular crop, we anticipate area expansion and large scale multiplication of quality planting materials of standardized improved varieties by developing strategic linkages with line departments and market stakeholders, as cashew is a candid crop for doubling farmers' income.

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