Research Achievements of AICRPDA Centre Ballowal Saunkhri since inception

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AICRPDA centre Ballowal Saunkhri is located in the agro-climatic Zone-l in the North-Eastern part of the Punjab. This zone popularly called *kandi* area is in the form of 10 to 20 km wide strip covering an area of approx 3.93 lakh hectares which comprises approximately 7.8 per cent of total geographical area of the State. The region stretches from Dhar Kalan block of Pathankot district to Dera Bassi block of SAS Nagar. The climate of the region varies between semi-arid to sub-humid. Rainwater constitutes the major water source for crops that becomes scarce due to erratic distribution in time and space. The region receives average annual rainfall of 800-1500 mm with a very high coefficient of variation. About 80% rain occurs in *Kharif* season (July-September) and rest 20% occurs in *rabi* season. A major portion (30-40%) of rain goes as runoff. Majority of the soils range from loamy sand to sandy loam and have low to medium moisture retention capacity and are highly erodible having gentle to moderate slope. The inherent fertility of the soils of this area is very low. Maize is the principal crop of *Kandi* area, beside this pearlmillet, greengram, blackgram and sesame are the other important *kharif* crops. Wheat, raya, taramira, lentil and gram are major *rabi* crops. The other emerging crops in the region are gobhi sarson, toria, linseed and arhar. The success of crops in this region depends upon the soil and water management.

With a view to maximize the crop productivity in this region, Indian Council of Agricultural Research (ICAR), New Delhi sponsored an All India Coordinated Research Project for Dryland Agriculture (AICRPDA) in September 1970 to Punjab Agricultural University, Ludhiana with centre at Hoshiarpur which is presently located at Regional Research Station (RRS), Ballowal Saunkhri (Shahid Bhagat Singh Nagar) as a coordinating centre with the following mandates:

- To optimize the use of natural resources in rainfed regions and to develop and promote technologies that lead towards minimizing soil and water loss and degradation of environment.
- To evolve simple technologies to substantially increase crop productivity and viability.
- To increase stability of crop production over years by providing crop management systems and alternate crop production technologies matching weather aberrations.
- To evaluate the traditional farming systems and study transferability of improved dryland technology to farmer's field.

Efforts are being made to increase the productivity in *Kandi* region

through efficient management of available water resources including harvesting of rain water and its judicious utilization along with integrated nutrient management through combination of organic and inorganic sources of fertilizers, tillage practices, crop residue management, crop diversification, contingency crop planning, intercropping, evaluation of improved varieties, energy management and farming system research. The centre has well-established Soil & Plant Sciences, Soil & Water Engineering, Plant Protection and Agro-meteorology laboratories with required equipments. During the last 48 years the centre has developed, refined and disseminated rainfed agro-technologies for the farmers of the region. The technologies being generated at this centre are also having relevance in the *kandi* region of adjoining states like Himachal Pradesh. The rainfed crop varieties and technologies developed at the centre are being adopted by the farmers of that region also. The five KVKs of the domain area help in dissemination of the technologies developed by the centre and provide feedback to the research being carried out at the station.

Recently new challenges are being faced by the farmers of the region because of changing climatic scenario and damage of crops by wild animals. The centre is working for the development of the technologies suitable under aberrant weather conditions. Now a close linkage has been developed with research and extension system of these adjoining state agricultural universities so that technologies developed by AICRPDA centre are disseminated to these regions also. Salient findings of the research conducted by the centre are given under different themes.

1. Rainwater Management

1.1 *In-situ* moisture conservation

1.1.1 Minor Land Shaping

Levelling of individual fields with minimum cut and fill with pre fabricated outlets for drop of <50cm, brick masonary structure for large drop, terracing, alongwith grassed waterways resulted low run off and soil loss and higher crop yields.

1.1.2 Pre monsoon ploughing

Ploughing of fields about a month before onset of monsoon results in more infiltrating water, low run off and soil loss. The effect was more pronounced in case of early withdrawn of monsoon.

1.1.3 Post- sowing tillage

Post-sowing tillage operation during *kharif* either as hoeing or inter-culturing (haloding) increased water intake, controlled weeds and act as soil

mulch reducing evaporation losses thereby enhancing maize yield.

1.1.4 Post harvest tillage

Repeated shallow tillage followed by planking immediately after harvesting of *kharif* crops helps in conserving moisture for the sowing of next rabi crop. Preferably the field is ploughed in evening and planked next morning to conserve dew drops fallen at night.

1.1.5 Mulching with Brought in organic mulch

Locally available shrubs like basooti (*Adhatoda vasica*), nara (*Arundodonax spp*) and Kanna (*Saccharum munja*) @4 t/ha applied in standing maize during last week of August resulted in higher soil moisture and higher wheat yields particularly in low moisture rainfall years. Mulching also improved yield of rainfed sugarcane crop.

1.1.6 *In-situ* raised mulch

In-situ raised mulch by growing green manure crops of sunhemp or cowpea in between the furrow of maize, which was cut at age of one month and spread in between the maize rows, resulted in significant increase in maize and wheat yields.

1.1.7 Cultivation across the slope

Cultivation across the slope reduces velocity of runoff water resulting in low soil loss and higher soil moisture content.

1.1.8 Vegetative barriers

Suitable grasses and bushes raised on field boundaries across the slope are the alternatives to bunding on arable lands resulting in increased soil profile storage and reduce soil erosion. In addition, napier bajra hybrid *(Pennisetum purpureum X typhoides*) gave higher biomass during initial years and kanna (*Sachharum munja*) gave higher mass in subsequent years.

1.1.9 *In-situ* moisture conservation in plantations

V-ditch and crescent bund methods of planting for horticultural and


V-ditch method of plantation


Mulching

forestry plants on sloppy lands harvest higher in-situ moisture. Success rate of plantation was higher by planting trees in V-ditches in clayey soils plant tree on upper side of ditch, whereas in soils with good infiltration rate, plants should be placed in ditch.

1.1.10 Precision levelling

In maize-wheat cropping system flat laser levelling of field helped in conserving 32.7% more moisture along with reduced runoff and soil loss and resulted in 15.5 % higher grain yield of maize over conventional levelling. It also resulted in highest BC ratio (2.17) and WUE (7.40 kg/ha-mm).

1.1.11 *In-situ* moisture conservation in maize-wheat cropping system

In maize *in-situ* moisture conservation practices like ridge planting, conservation furrows and bed planting resulted in significant increase in the yield of maize over flat sowing with a respective increase 17.4, 15.1 and 10.3 per cent. The yield of succeeding rainfed wheat in ridge sowing and conservation furrow plots of maize increased by 20.3 and 15.7 per cent respectively over flat sowing.

1.2 *Ex-situ* moisture conservation

1.2.1 Excavated and impounded type of water harvesting structures

In *Kandi* region it is estimated that 25 to 45% of the monsoon rain is lost as run off. The run off water can be harvested in excavated or impounded type reservoirs and can be used for irrigation and other purposes. To reduce seepage losses, 800 gauge(200µ) polythene sheet covered under 20cm layer of soil was quite effective for lining tank bottoms, whereas brick and cement lining (7.5cm thick) was effective for lining the sides of tank.

1.2.2 Makkowal type water harvesting structure

Perennial flow on base flow from the drainage line was harvested at Hoshiarpur district of Punjab for the first time with technical support of

AICRPDA, Ballowal Saunkhri. The model was replicated with the help of World Bank at many locations in *Kandi* region.

1.2.3 Reuse of harvested rainwater

Use harvested water for pre-sowing irrigation in case of deficit seed zone moisture for *rabi* crops. If seed zone moisture at sowing is sufficient, one supplemental irrigation to wheat at crown-root initiation is best. The irrigation to wheat at large areas was found beneficial over two irrigations on smaller area. If there is dry spell during tasselling and pollination phase of maize crop, use harvested water as life saving irrigation.

1.2.4 Catchment storage command relationship

Application of one supplemental irrigation to maize & okra during dry spell, at CRI stage to wheat and as pre-sowing irrigation to pea gave 50, 51, 93 and 100% respectively higher yield over rainfed conditions. The catchment-storage, catchment command and storage command ratio of the water harvesting system were 12.7, 6.86 and 0.54 respectively.

2. Cropping Systems

2.1 Crops and cropping system available for the region

Maize was found to be most suitable and assured crop during *kharif* season. In case of sandy soils with low moisture holding capacity pearl millet for fodder purpose performed better than maize. Performance of rabi crops was better after summer fallow than after maize. The combined yield of two crops per year was always considerably than that of a single rabi crop. Maize-Wheat sequence was best in years of favourable rainfall whereas Maize-Wheat+Gram sequence performed better in low rainfall years. Sunflower and safflower can be cultivated successfully under rainfed conditions.

2.2 Green manuring and use of leguminous crops

The yield of *rabi* crops was better after green manuring rather than after maize crop or after summer fallow. Growing of short duration legume crop of moong gave an additional yield of 3 to 4 q/ha and proved even better than green manuring. Green manuring with 40 days old sunhemp crop was better than that of 30, 50 or 60 days old crop in terms of wheat yield.

2.3 Inter-cropping

- Sowing of 2-4 rows of pearl millet around maize fields saved maize crops from animal and human damage, worked as wind break and provided fodder for livestock.
- Wheat+Raya in rows (One row of Raya after every 12 rows of Wheat)

proved more remunerative compared to wheat alone.

- Intercropping of green gram/black gram between two rows of maize spaced 50 cm gave higher maize equivalent yield as compared to sole maize.
- Intercropping of green gram in paired row of maize(30/60 cm) resulted in highest maize equivalent yield followed by black gram.
- Raya intercropping in wheat and gram at 3.0 m apart in north-south direction and in lentil at 2.0 m apart provided additional income and covered the risk at crop failure under rainfed conditions.

2.4 Double Cropping

- Soils of high and medium water holding capacity were suitable for maize- wheat system.
- If sufficient moisture is available after *kharif* crop, raya in rabi is most profitable.
- On sandy soils with low water holding capacity summer fallow was better than double cropping.
- Total productivity of cropping sequence was higher in black gram-raya, maize-raya and maize-chickpea sequence or compared to traditional maize-wheat sequence. Thus, cultivation of raya and chickpea was found to be more profitable when grown after blackgram maize crops respectively.

2.5 Seed rate, spacing and sowing time

- Sowing of Castor at 75 cm row spacing was better than higher row spacing.
- Sowing of maize hybrids at 45 X 22.5 cm spacing was better than 60 X 22.2 cm spacing in rainfed conditions.


Wheat: Raya intercropping


Toria: Gobhi Sarson intercropping

- Optimum sowing window for chickpea under rainfed condition is 20th Oct to first week of November.
- For lentil seed rate of 30 kg/ha row to row spacing of 25 cm was better as compared to other treatments.

2.6 Integrated Weed Management

The combined application of Trifluralin (0.5 kg/ha) as pre-emergence and one hand-weeding at 30 DAS resulted in higher seed yield of green gram and black gram.

2.7 Preparatory Contingency Crop Planning

2.7.1 Contingency crop planning for light textured soils

In light textured soils, for timely onset of monsoon the preference of *kharif* crops should be blackgram, pearl millet (grain), maize, pearl millet (fodder), sesame and greengram. If sesame crop is to be grown, it can be sown after 15th July. For late sowing, the preference of *kharif* crops should be pearl millet (grain), blackgram, maize (fodder), pearl millet (fodder), greengram and sesame.

In *rabi* for timely sowing of crops under low moisture conditions due to early withdrawal of monsoon and no winter rains, taramira crop should be preferred. For late sowing of *rabi* crops under low moisture conditions crops like taramira, lentil and raya are to be preferred compared to wheat, barley and triticale.

2.7.2 Contingency crop planning for medium textured soils

In medium textured soil to find suitable seasonal crop for early, mid and late monsoon onset conditions, the crops were sown at different intervals. In case of timely onset of monsoon i.e. from 20 June to 5 July maize was most desirable crop be sown without reduction in yield. If monsoon rainfall is received from 5 to 15 July then blackgram, geeengram and sesame should be preferred over maize crop. If monsson rainfall is further delayed then green gram can be sown upto 30 July.

In *rabi*, all the crops like wheat, raya, chickpea and taramira sown in the month of October gave lower yield than sowing in mid-November and last week of November. Sowing in mid-November gave higher wheat equivalent yield (WEY) in all the crops.

2.8 Real time contingency crop planning

Based on the experiments conducted at the station and on the farm the following real time contingency measures have given promising results in alleviating moisture stress in crops during dry spells and low moisture

conditions:

2.8.1 Real time contingency measures for *kharif* cropping

Scenario I: Normal onset of monsoon and early stress

- Creation of soil mulch with improved wheel hand hoe to prevent the loss of soil moisture and to control weeds
- Removing of weaker plants to reduce plant population
- Application of foliar spray of 1% KNO_3
- Use of harvested rainwater for life saving irrigation
- Removal of weeds to avoid competition for water
- In case of crop failure growing of alternate crops like sesame, blackgram and greengram up to mid July
- If crop fails due to the prolonged dry spell then fodder bajra may be sown in the month of August.

Scenario II: Normal onset and mid season stress

- Application of supplemental irrigation, if available
- Removal of less vigorous plants up to 20% and use as fodder
- Application of foliar spray of 1% KNO_3 at pre tasselling stage
- Removal of weeds to avoid competition for water.
- Application of locally available vegetative mulch material in between crop rows

Scenario III: Normal onset and terminal stress

- Application of supplemental irrigation, if available.
- Removal of cob less plants and using them as fodder.
- Harvesting and selling of green cobs in market, if crop is at milking stage.
- Harvesting and vertical staking of the crop at dough stage,.
- Vacating the field early where the crop has failed or matured early due to moisture stress and immediately ploughing the field to conserve moisture for *rabi* crops.
- Sowing of toria after the vacation of field followed by sowing late sown variety of wheat like PBW 658 and PBW 590 after the receipt of winter rains in December compensates the loss due to failure of *kharif* crop.

Scenario IV: Delayed onset of monsoon

- If monsoon onset is delayed by 15 days sow alternate crops like greengram, blackgram and sesame.
- If monsoon onset is delayed by 30 days sow greengram for grains or pearl millet for fodder.

2.8.2 Real time contingency measures for *rabi* cropping

Scenario I: Low soil moisture at sowing

- Placing the seed in the moist soil zone ensures uniform germination of the crop.
- Sowing of wheat at wider row spacing of 30 cm is better than sowing at row to row spacing of 22-25 cm.
- Chickpea, linseed and rapeseed and mustard perform better than wheat in low soil moisture.
- Sowing of chickpea after seed priming in molybdenum solution (1 g molybdenum per 2 liters of water) ensures better germination and higher yield of the crop.
- Sowing of wheat crop after soaking seed in thiourea solution (1 g thiourea per liter of water) results in uniform germination and higher yield.
- Late sown varieties of wheat like PBW 658 or PBW 590 may be sown after the receipt of winter rains.

Scenario II: Failure of winter rains

- Apply supplemental irrigation from the harvested rain water to save the crop.
- Application of foliar spray of thiourea solution (1g thiourea per liter of water) to wheat at maximum tillering and bootin stage increases grain yield.


Alternate *rabi* crops


Strip intercropping

2.9 Strip-intercropping

Cultivation of maize and cowpea on 1% slope gave significantly higher yield (3331 kg/ha), net returns (Rs.23202 /ha), BC (1.75) and WUE (6.22 kg/ha/mm) than 2% and 3% slope. A strip intercropping system with maize strip width of 4.8m and cowpea strip width of 1.2 m (4.8:1.2) gave significantly higher MEY (3862 kg/ha) over maize: cowpea strip width of 3 m: 3m, 1.2 m: 4.8 m and sole cowpea with a respective increase of 8.9, 17.8 and 32.8 per cent with highest LER (1.22), net returns (28428/ha) and WUE (7.18 kg/ha/mm).

3. Nutrient Management

3.1 Nutrient Management in kharif crops

3.1.1 Maize

- In Sandy loam soils having medium water storage 80 kg N/ha is optimum whereas for loamy sand soils with low water storage 40 kg N/ha is optimum.
- The response to applied P was observed only for soils testing low in available P and that too only upto 20 kg P_2O_5/ha .
- All source of N is urea, Calcium ammonium nitrate and ammonium chloride were at par.
- All source of N in two splits i.e. ½ at sowing and ½ at knee high stage proved slightly better than full N at sowing. Foliar application of N was not beneficial.
- Application of 10 t/ha FYM increased maize yield by about 3q/ha but the effect was observed in low N application only.
- Application of crop residues reduced maize yield by 50% as compared to control. During initial initial two years, application of wider C:N ratio plant residues alone (maize stover and wheat straw) showed depressing effect but during 3rd year onwards the response was encouraging.
- Equal yields were obtained with 100% inorganic N on 50% organic +50% inorganic N.
- Application of 40 kg K_2O/ha resulted in 18.6 and 10.7 per cent higher grain yield of maize over control and 20 kg K_2O/ha, respectively. Magnesium sulphate application @ 45 kg/ha improved yield of maize.

3.1.2 Fodder Crops

- Bajra and fodder Sorghum responded to N upto 50 kg/ha.

- Napier bajra hybrid responded upto 50 kg/ha applied after each cutting.

3.1.3 Sugarcane

- Cane yield was doubled with fertilizer application as compared to control.
- Application of 12.5 t/ha FYM increased cane yield by more than 100 q/ha over control
- Response to N was observed upto 100 kgN/ha with and without FYM.

3.1.4 Greengram

Application of P_2O_5@ 20 kg/ha is sufficient to get optimum yield of greengram under rainfed conditions.

3.2 Nutrient Management in *Rabi* Crops

3.2.1. Wheat

- Earlier tall wheat varieties line C-306 responded upto 30 kgN/ha only in loamy sand soils.
- High yielding later varieties responded upto 80 kg N/ha in medium storage soils and upto 120 kg N/ha in soils of high moisture storage.
- Different sources of N like urea , calcium ammonium nitrate and ammonium chloride were equally effective however ammonioum chloride was slightly inferior in performance.
- Application of half of recommended N as basal and remaining half with winter rains proved economical.
- Earlier tall wheat varieties were not responding to P application but later dwarf varieties responded upto 20 and 40 kgP_2O_5 in loamy sand and sandy loam soils respectively.

3.2.2 Gram (Chickpea)

- Response of gram to P application on soils with 16 kg available P_2O_5/ha or less, was upto 20 kgP_2O_5/ha.
- In Wheat+gram mixture, response to N was observed upto 60 kgN/ha in clay loam and sandy loam soils, whereas it was upto 20 kgN/ha in loamy sand soils.
- Seed priming of gram with molybdenum increased seed yield upto 0.5g/litre of water compared to control.
- Application of P+S to rainfed gram gives highest seed yield.

- Seed inoculation with *Rhizobium* gave better yield and economic returns than control.

3.2.3 Lentil

- Seed inoculation with *Rhizobium* culture and fertilizer application of N @12.5 kg and P_2O_5@20 kg/ha gave higher crop yields.
- Green manuring with green gram alongwith recommended fertilizers gave highest yield.

3.2.4 Oilseeds

- Application of 50 kgN/ha to sole toria , 75 kgN/ha to sole gobhi sarson is optimum.
- For toria-gobhi sarson intercropping system, application of 30 kgN/ha to toria and 25 kg N/ha to gobhi sarson at sowing and 25 kg N /ha after the harvest of toria.

3.2.5 Maize-wheat cropping system

- In maize-wheat cropping system application of FYM @10 t/ha benefitted both maize and wheat crop in normal rainfall years.
- In maize-wheat sequence when FYM is applied to maize, a saving of 50% N can be made in case of the succeeding wheat crop.
- Wheat crop responded upto 20 kgP_2O_5/ha but there was no residual effect of P applied to maize on wheat. Long term application of P to wheat showed its residual effect on maize crop.

3.2.6. Integrated Nutrient Management

- Application of 6 t/ha FYM + 40 kgN/ha to maize and 60 kgN/ha to wheat gave best results in maize-wheat cropping system.
- In maize-wheat system 15 kgN/ha through compost and 20 kgN/ha (inorganic) was equally good.
- In maize- wheat cropping system application of 80 kg N through urea or 40 kg N through urea + 40 kg N through compost produced significantly higher grain yield of maize and wheat and thereby resulted in significantly higher system productivity.

4. Long term experiments

4.1 Tillage and nutrient management

In maize-wheat rotation, 50% conventional tillage+interculture+ chemical weed control was at par with conventional tillage+interculture, thus

saving two tillage operations. Among N sources, application of 100%N through urea gave best results.

4.2 Permanent manurial trial

In maize-wheat cropping system, application of 100% recommended NPK + FYM @ 10 t/ha gave highest yield of maize and wheat which was significantly higher over all other treatments.

5. Crop Improvement/Evaluation of drought tolerant varieties

5.1 Maize

Local varieties were sown earlier which were maturing earlier resulting in more residual soil moisture and better *rabi* crop yields but these were replaced with composites and hybrids because of their low yield potential. Prominent composite varieties were Megha and Kesari whereas prominent recommended hybrids were Prakash, JH 3459 and PMH 2.

5.2 Bajra

HB-1 was best variety in seventies, followed by PHB 47, PCB 8 and PHB 10, PCB 15 and PCB 138 in eighties and nineties. In the beginning of twenty first century PCB 164 and PHB 2168 were recommended for grain purpose and FBC 16 and PHBF-1(hybrid) for fodder purpose.

5.3 Sesamum

Earlier sesamum IVI 24 was best but later on, TC 289, RT 346,Punjab Til No. 1and Punjab Til No.2 were recommended.

5.4 Mash

Mash 1-1 in seventies, Mash 48 and then Mash 338 and Mash 114 were recommended.

5.5 Moong

ML 131 and ML 267 were earlier varieties which were replaced by ML 613, ML 818 and PAU 911 under rainfed conditions.


Maize variety PMH-2


Moong variety ML-818

5.6 Wheat

In late seventies under low rainfall conditions tall variety C 306 was best but in normal rainfall years dwarf varieties WL 357, WL 410 and PBW 2265 were better. Later on PBW 175, PBW 299, PBW 644 and PBW 660 were recommended for cultivation.

5.7 Barley

In recent years PL 426, PL 56 and PL 419 were found better than local varieties.

5.8 Gram

Till early eighties C 235 was best variety. Later on PBG 1, PBG 5 and PBG 7 were recommended.

5.9 Lentil

Earlier L 9-12 was best but later on LL 699 and LL 931 were recommended.

5.10 Raya

Earlier RL 18 and T 59 were significant but later on PBR 91, PBR 97 and RLM 619 were tested and released.

5.11 Taramira

TMLC 2 variety of taramira was recommended.

5.12 Linseed

LC 54 variety of linseed performed well in dry land conditions.

5.13 Crops for animal damage prone areas

- Safflower strains ISF-1, SPP-A-129 and MKH-9 were better than local check Bhima. Because of thorns this crop is not damaged by wild animals.
- Sesamum during *kharif* season and taramira during *rabi* season are suitable alternate crops as they perform better than other crops in animal damage prone areas.


Gram variety PBG-5


Wheat variety PBW-660

6. Energy Management/ Farm Mechanization

In maize-wheat cropping system, conventional tillage (Disc harrow + cultivator + planking) resulted in 15.0 and 5.0 % higher grain yield of maize and wheat over rotavator.


Chiselling


Bed planting with Tractor

7. Alternate Land Use System

7.1 Agro-forestry

Planting of Kikar (*Acacia nilotica*) and Safeda (*Eucalyptus spp*) in blocks at 3 x 5 m spacing performed best. Under these trees in *kharif* season fodder crops and in *rabi* season oilseed crops can be grown.

7.2 Agro-horticulture

- Amla, Galgal, Ber, Guava and Mango can be grown in rainfed *kandi* region. These trees can be planted at 7.5 x 7.5 m distance.
- Upto the age of 4 years of these trees, intercropping with leguminous crops can be done.
- Grasses could also be grown successfully as intercrops in these orchards.
- Fruit based agro-horticulture system like Amla+Blackgram, Guava+Blackgram during *kharif* and Amla+taramira, Guava+Taramira, Amla+ lentil and Guava + Lentil during *rabi* were better than annual crops.


Guava and Amla based agro-horticulture systems