



# Participatory Innovation Platform on Potential Yield Realization of Maize-based Cropping Systems in Punjab and Haryana



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Rice-wheat system of the North-West India have contributed immensely to national food basket over past 5 decades. However, over time the sustainability of the intensive rice-wheat systems of North-West India has become a major challenge owing to faster depletion of groundwater table, stagnating or declining productivity growth, degrading soil health and environmental quality including air pollution and public health concerns, and diminishing farm profitability. Furthermore, projected climate change will increase future water demand for irrigation by ~10% with each °C rise in temperature whereas the availability will decline in the areas where irrigation is most needed. On the other hand, increasing demands on water resources by increasing population and urbanization have reduced the water availability. Per capita water availability in India is lower than the world average, and is extremely stressful in the Indus Basin and has more than halved over the last two decades in India. Therefore, by 2050, India would face severe water constrains for both agriculture and domestic use.

Rice is a water-guzzling crop and consumes significant amount (about 50%) of total irrigation water use in Asia and it accounts for about 24–30% of the world total freshwater withdrawal. India ranks number 1 in withdrawal of fresh water with a total of about 761 billion m<sup>3</sup> per year of which about 90% is used for agriculture. Most of this fresh water withdrawal is in Northwestern states of India where every year there is net negative balance in withdrawal and replenishment of water primarily due to rice crop. The decline in ground water table in north-west India between 1973 and 2001 was about 0.2 m yr<sup>-1</sup> which has accelerated by five-fold (1.0 m yr<sup>-1</sup>) between 2000 and 2006 and even higher than 1.0 m yr<sup>-1</sup> in recent years. This has also led to increased energy demand for pumping and increased costs for installing deep submersible pumps. If sustainable measures are not taken soon to ensure sustainable use of groundwater, the north-western India may soon experience reduction of crop productivity and farm profitability, and shortages of potable water leading to extensive socioeconomic stresses.

The threat will further be intensified as many river basins in the region are likely to witness physical water scarcity by 2050 and rainfall, a major source of freshwater, is expected to be also severely affected by projected changes in global climate, caused by higher concentration of greenhouse gases. However, improvements in water use efficiency, the amount of food produced per unit of water consumed, have the potential to improve both food security and water sustainability. Therefore, there is an urgent need to develop and implement strategies for protecting the ground water for the future generations. Considering the seriousness of the issue, on, 25<sup>th</sup> December 2019, Honourable Prime Minister of India launched the “*Atal Bhujal Yojna*” for sustainable use and conservation of ground water resources.



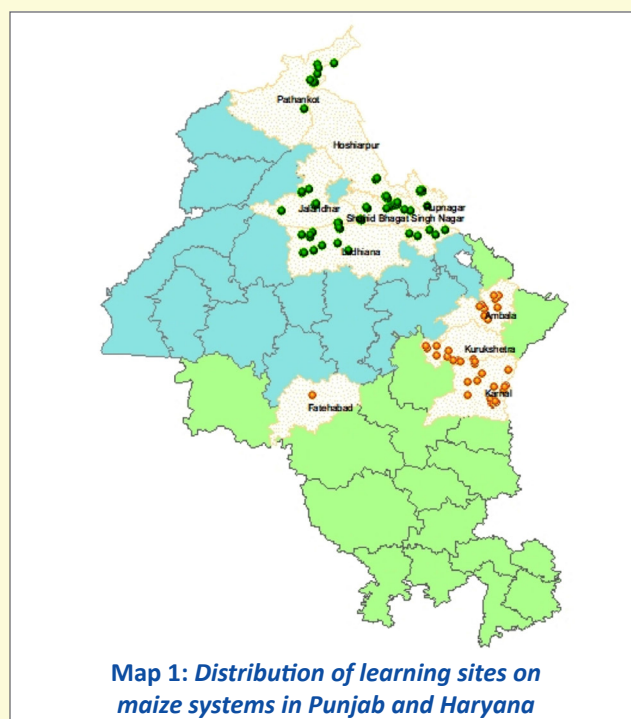
Diversification of rice crop is the need of hour to sustain the declining natural resources to ensure food security in long-run in the Punjab and Haryana. Though there are range of technologies, practices and strategies available for agricultural diversification in north-west India but their applications, accessibility, affordability, market linkages and investment priorities are very

situation-specific. The following sections enlist the major diversification options and strategies for diversification.

In north-west India, the major strategy should be on 'Re-designing intensive rice-wheat systems through diversification of rice along-with bundling precision agronomic innovations for transitioning towards agricultural sustainability'. In this respect, diversification of rice with alternate and equally ruminative crops such as maize has been found as sustainable alternatives for coping above said problems. Sustainable intensification of maize systems can potentially save 60-75% irrigation water, 70% of energy consumption and reduced greenhouse gas emissions as compared to rice systems. Besides, several environmental benefits, maize cultivation could be an alternative solution to prevent residue burning in these regions, and therefore improvement in soil physical properties and biodiversity with lesser ground water pollution would happen in long-run. Having maize in rotation has yield advantages to wheat compared to rice in addition to providing additional window for a short duration legume during summer and hence higher system productivity and resource use efficiency. Moreover, complete mechanization of maize production crop from sowing, harvesting and drying provides ample opportunity to cultivate it with conservation agriculture with efficient residue utilization and recycling.

At present domestic demand for maize in the region (Punjab and Haryana) stood over 28 to 31 lakh tonnes primarily for poultry (22-25 lakh tonnes) and starch (6 lakh tonnes) industries. These states also need maize for livestock feed, green fodder, silage, food and value addition. In future, high growth rate of poultry industry (>10% per year) and demand for ethanol/brewery/alcohol and polyacrylic acid (PLA) for bio-plastic will enhance maize demand. Hence, present production of nearly 4.5 lakh tonnes requires good agronomic practices for enhancing its production to thrive these industries and further employment generations.

The Government of India has taken several steps to diversify the rice-wheat cropping system in Punjab and Haryana. The Government of Haryana took a good initiative to diversify the 50000 ha rice with maize crop during kharif 2019 by incentivizing free seed along with contribution of farmer share through crop insurance and procurement at minimum support prices (MSP). Further, Government of Haryana implemented ***Mera Jal Meri Virasat Yojna*** for promotion of rice diversification in which seed, cash incentive (Rs. 2000/acre) and assured procurements are given to alternate crops like maize. However, as maize became non-traditional crop in this ecology the stakeholders need handholding and strategy for its promotion is needed with best production practices. Therefore, Secretary DARE & Director General, ICAR, New Delhi has advised to establish participatory innovation platforms of maize system with value chain for diversification of rice in Punjab and Haryana. The ICAR-Indian Institute of Maize Research (IIMR), Ludhiana in collaboration with International Maize and Wheat Improvement Center (CIMMYT), India in consultation with State Departments of Agriculture in Punjab and Haryana and other key stakeholders have established the participatory learning platforms in Punjab and Haryana (Map 1).



**Map 1: Distribution of learning sites on maize systems in Punjab and Haryana**

The demonstrations are planning to conduct maize-wheat-mungbean or maize-mustard-mungbean cropping system or other vegetable based maize systems to document benefits and plan strategy and future pathways for diversification (Table 1).

**Table 1. Potential areas identified for experiential learning platform for potential yield demonstration in maize systems.**

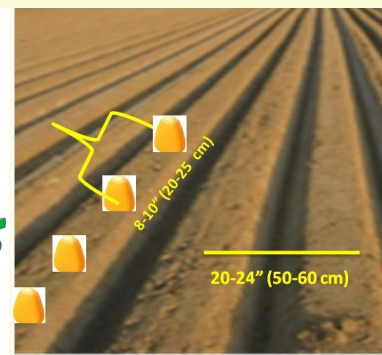
District	Blocks	No of Learning Sites
Jalandhar	Sahahkot, Nakodar and Jalanadhar west	8
Hoshiarpur	Garshankar and Mahlpur	12
SBS Nagar	Saroya, NawaShasher, Balachur and Aur	15
Rupnagar	Chamkaur sahib, Ropar, NurpurBedi and Anadpur Sahib	18
Pathankot	Pathankot, Gharota, Dharkdan and Naloh	16
Ludhiana	Jagraon, Ludhiana and Sidhwa	14
Karnal	Assandh, Karnal, Kunjpura, Nilokheri and Nissing	21
Kurukshetra	Thanesar, Pehowa and Ladwa	17
Ambala	Ambala-2, Saha and Sahzadpur	15
Fathehabad	Ratiya	2



**Fig 1. Maize-wheat/mustard-mungbean in conservation agriculture with retention of maize residue.**

#### Advantages of maize diversifying rice

- » 90% water saving; 3 crops with much lesser water than rice
- » 70% energy saving
- » Higher wheat yield by ~10% due to enhanced sowing window and better soil environment
- » Reduced problem of *Phalaris minor* in winter crops
- » Timely planting of crops in sequence
- » More suitable for conservation agriculture
- » Improved soil physical condition and health
- » No crop residue burning



**Maize planting**



**Weed control up to 20-25 days by Atrazine application**



**Tembotrione in standing crop**

### Setting-up the participatory innovation platforms

- » Baseline characterization for identifying the potential farmers and fields for diversification.
- » Stakeholder consultations (specially with state department of agriculture, Govt of Punjab, Haryana, industry and FPOs).
- » Awareness campaigns.
- » Developing packages of practices for diversification options using existing knowledge base.
- » Farmers training programs on diversification and management practices for new crops (maize).
- » Establishing/conducting 150 demonstration on diversification of rice with maize in 53 villages.
- » Establishing/linking pilot driers (for drying maize and linking to market).
- » Linking the farmers with market (local poultry feed industry, starch mill and soya product mills etc) to develop a scaling model.

- » Ex-ante assessment for potential of diversification opportunities in north-west India through linking the government's schemes on diversification, **Atal Bhujal Yojana**, **Jal hi Jeevan** scheme etc.

### Key features of demonstration platforms

- » Family labour imputed is very high in these states, the mechanization of cropping system will be focused for sowing, inter-culture, harvesting and drying with the available latest machinery.
- » Available machinery hubs and custom hiring centres could be roped in to strengthen maize production.
- » Size of the demonstrations: one-acre land preferably.
- » Operations to be emphasized: Planting, herbicide spray, earthing up, pesticide spray, harvesting, drying, market linkages.
- » Seed, sowing, pesticide for insect, weed control to be supported in demonstration.

**The key operation to be undertaken for higher potential yield realization of maize systems is given as follows:**

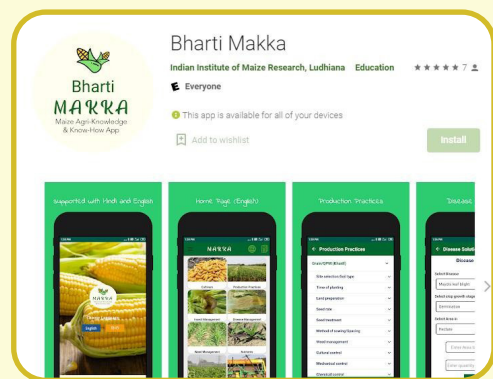
Practice/ Item	<i>Kharif (Maize)</i>			
Field preparation	Well prepared seed bed with proper irrigation and drainage system. Maize is also recommended for sowing under zero-tillage condition in maize-wheat-mungbean system.			
Selection of cultivars	CP858, Drona, DKC9164, P3544.			
Seed Rate	8 kg/ acre.			
Seed Treatment	Cyantranilprole 19.8% + Thiamethoxam 19.8% FS (Fortenza Duo) @ 6 ml/kg to control fall armyworm protects the crop for initial 20 days. Bavistin or Derosil or Agrozim 50 WP (carbendazim) @ 3 g/kg of seed for fungal diseases.			
Sowing time	First week of June to First week of July.			
Sowing Method and spacing	Sowing to be done 3-5 cm deep in lines with a raised bed maize planter or seed cum fertilizer drill or pneumatic planter with a spacing of 60 cm x 20 cm or 50 cm x 25 cm.			
Weed Control	Spray Atrataf 50 WP (atrazine) @ 800 g/acre on medium to heavy soils and 500 g/acre in light soils using 200 litres of water within 2 days of sowing. If pre-emergence herbicide not applied, apply 400 g atrazine 50 WP + any of the following post-emergence herbicide as tank-mix application 15-20 days after planting. At 20-30 days after sowing, apply any of the following post-emergence herbicide.			
	<b>Name of herbicide</b>	<b>Dose/acre</b>		<b>Effective to control</b>
		<b>a.i.(g)</b>	<b>Formulation (g or ml)</b>	
	2,4-D Dimethyl Amine salt 58% SL	200.00	344.0	Broad leaved weeds
	Halosulfuron Methyl 75% WG	27.00	36.0	Sedges
	Pyroxasulfone 85% w/w WG	51.00	60.0	All weeds
	Tembotrione 34.4% SC	48.00	114.4	All weeds
	Topramezone 336 g/l w/v SC	10.08 + MSO adjuvant	30 + MSO adjuvant @ 2 ml/l	All weeds
	Mesotrione 2.27% w/w + Atrazine 22.7% w/w SC	120	350	All weeds
Nutrients' requirement	N: 110 kg/acre of urea P: DAP 55 kg/acre or superphosphate 150 kg/acre or nitro phosphate 125 kg/acre. K: Based on soil test only. Apply one third of nitrogen and entire amount of phosphorus and potassium at the time of sowing, one third nitrogen at knee high stage and remaining at pre tasseling stage. Note: If 55 kg of DAP is used then apply only 90 kg of urea. Apply 60 kg of urea if 125 kg of nitro phosphate is used.			
Irrigation	Maize requires maximum 4-6 irrigations. Critical stages for irrigation: pre-tasseling, silking, grain filling.			

Practice/ Item	Kharif (Maize)
Plant protection	<p>Fall armyworm and borer can infest crop from June to September. Spray in whorl either Emamectin benzoate 5% SG (Proclaim/Missile/Spolitetc) @ 0.4 g/l water or chlorantraniliprole 18.5% SC (Coargen) or Spinetoram 11.7% w/w SC (Delegate/largo) @ 0.4 ml/l water or Chlorantraniliprole 9.3% + Lambda cyhalothrin 4.6% ZC (Ampligo) @ 0.25 ml/l. Rotate the pesticide in next spray for effective control.</p> <p>Biopesticide <i>Bacillus thuringiensis</i> var <i>Kurstaki</i>, NPV @ 2 g/l or <i>Metarhizium anisopliae</i>, <i>Metarhizium rileyi</i> (<i>Nomuraea rileyi</i>), <i>Beauveria bassiana</i>, <i>Verticillium lecanii</i> @ 5 g/l is also effective.</p> <p>The selected infected plants can also be sprayed using small sprayer.</p> <p>Drenching of the field with bleaching powder, if there is incidence of bacterial stalk rot.</p>
Harvesting and drying	<p>Harvesting the crop when black layer formed at proximal end or husk is dried. Harvest crop by hand as stalk cut or cob removal or with reaper or combine. Maize dehusker or sheller can be used for grain separation from cob. Do not heap the grain until properly dried. The harvested grain to be dried by mobile or stationery dryer and crop to be sold or stored at &lt;14% moisture content. It will improve quality and reduce aflatoxin contamination which helps in better price realization.</p>
<b>Rabi (wheat/mustard).</b>	
Field preparation	The wheat and mustard after maize can be sown under zero-tillage conditions.
Selection of cultivars	<p><b>Wheat:</b> HD 3226, HDCSW 18 (October planting), DBW 187, HD 3086, DBW 222 (November planting).</p> <p><b>Mustard:</b> PBR 357, RGN 229, Pusa Mustard 29 and 30, PDZ 1, LES 54, Coral PAC 437, GSC-7 (Gobhi sarson).</p>
Seed Rate	Wheat: 40 kg/acre for wheat and 2 kg/acre for mustard.
Sowing time	<p>Last week Spetember-15 October for mustard.</p> <p>15 October to 15 November for wheat.</p>
Sowing Method and spacing	On raised bed two rows or in pneumatic planted maize three rows can be sown on a bed for wheat. For mustard, two rows can be sowed on either side of one maize row. Use happy seeder or zero till bed planter for sowing the crop.
Weed Control	<p>Maize reduces the infestation of the <i>Phalaris</i> in winter crops.</p> <p>For wheat:</p> <ul style="list-style-type: none"> <li>» Pendimethalin 30% EC @ 1.00 litre /acre as pre-emergence application.</li> <li>» Post-emergence herbicides at 30 DAS, choose as per weed flora from the following:</li> <li>» For broad leaved weeds: 2,4-D 58% SL(Weedmar)@ 400-500 ml/acre or Metsulfuron Methyl 20% WP (Algrip) @ 10 g/acre.</li> <li>» Both broad-leaved weeds and grasses: Sulfosulfuron 75% WG (leader) @ 13 ml/acre.</li> <li>» For grassy weeds: Clodinfop-propagyl 15% WP (Topik) 165 g/acre.</li> <li>» Wild oat and <i>Phalaris</i> minor: Fenoxaprop-p-ethyl 10% EC (Puma Super) 400 ml/acre.</li> </ul> <p>For mustard:</p> <ul style="list-style-type: none"> <li>» Fluchloralin 42% EC (Basalin) @ 950 g/acre as pre-emergence application.</li> <li>» Isoproturon 75% WP (Arilon) @ 400 g/acre at 30 days after sowing.</li> </ul>
Nutrients' requirement	<p><b>Wheat (quantity/acre):</b> 52 kg DAP, 23 kg urea, 27 kg MOP as basal; 45 kg urea each at first and second irrigation.</p> <p><b>Mustard (quantity/acre):</b> 35 kg DAP, 8 kg S/sulphur and 25 kg urea at basal; 40 kg urea at branching stage.</p>

Practice/ Item	Kharif (Maize)
Irrigation	<b>Wheat:</b> required 4-6 irrigations; apply at CRI, tillering, jointing, flowering, milking and dough stages. <b>Mustard:</b> requires 2-3 irrigations; apply at branching and pod formation stage specially.
Harvesting and drying	Harvest the mustard when pod turn yellow. Wheat can be harvested using combine. <b>Spring (mungbean).</b>
Field preparation	The mungbean after wheat and mustard can be sown under zero-tillage conditions.
Selection of cultivars:	Pusa 1431, SML 668, SML 823, MH 421, MH 1142, Samrat, Virat.
Seed Rate	10-12 kg/acre.
Sowing time	Just after harvesting of the mustard or wheat crop in March-April.
Sowing Method and spacing	Sowing can be done through happy seeder or zero-till seed drill under zero-tilled conditions.
Weed Control	Apply pendimethalin @ 1 litre/acre.
Nutrients' requirement	30-35 kg DAP/acre at sowing.
Irrigation	Apply first irrigation at 20-25 days after sowing and subsequent at 20 days intervals depending on the weather situations. Good moisture availability at flowering is needed for higher yield.
Harvesting	The pods can be hand-picked twice or whole plant harvesting or combine can also be used for harvesting when 90% pod matures.

### Expected outcome

1. Portfolio of practices for sustainable intensification of maize systems.
2. Multi-criteria (yield, income, water, energy, environmental footprints) analysis of maize system *viz-a-viz* rice systems and their participatory validation for diversification of rice in western IGP.
3. Multi-stakeholder participatory co-learning for sustainable production and value chains in maize system.
4. Science evidence-based policy recommendations for diversification in western IGP.
5. Enhanced capacity of value chain actors and recommendation domains for diversification and sustainable intensification of production systems in Western IGP.



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