Progress and Prospects of the Rice-Wheat Cropping System in the Indo-Gangetic Plains (IGP) since the Green Revolution



R. K. Malik

Senior Agronomist, CIMMYT-India, rk.malik@cgiar.org

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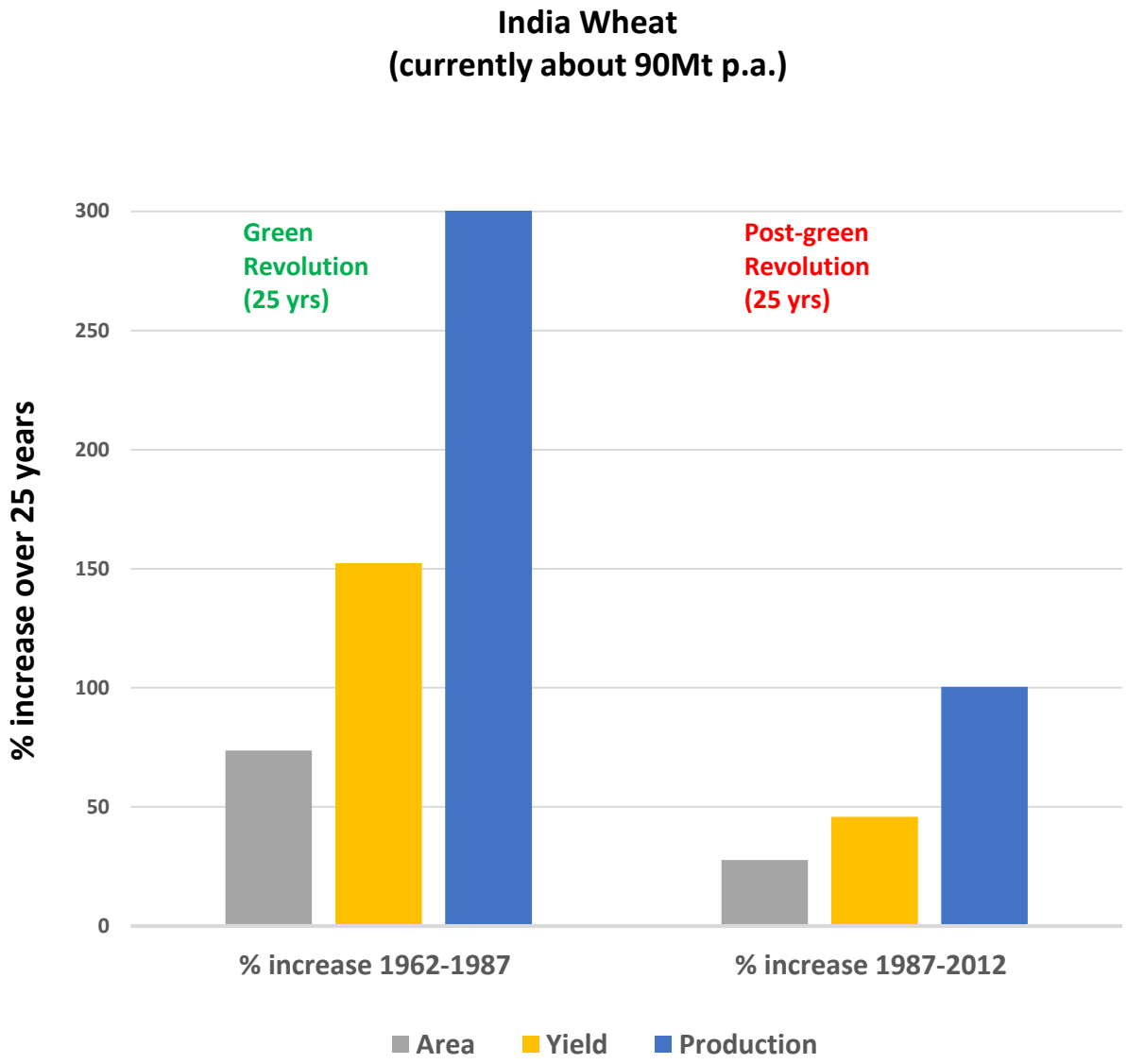
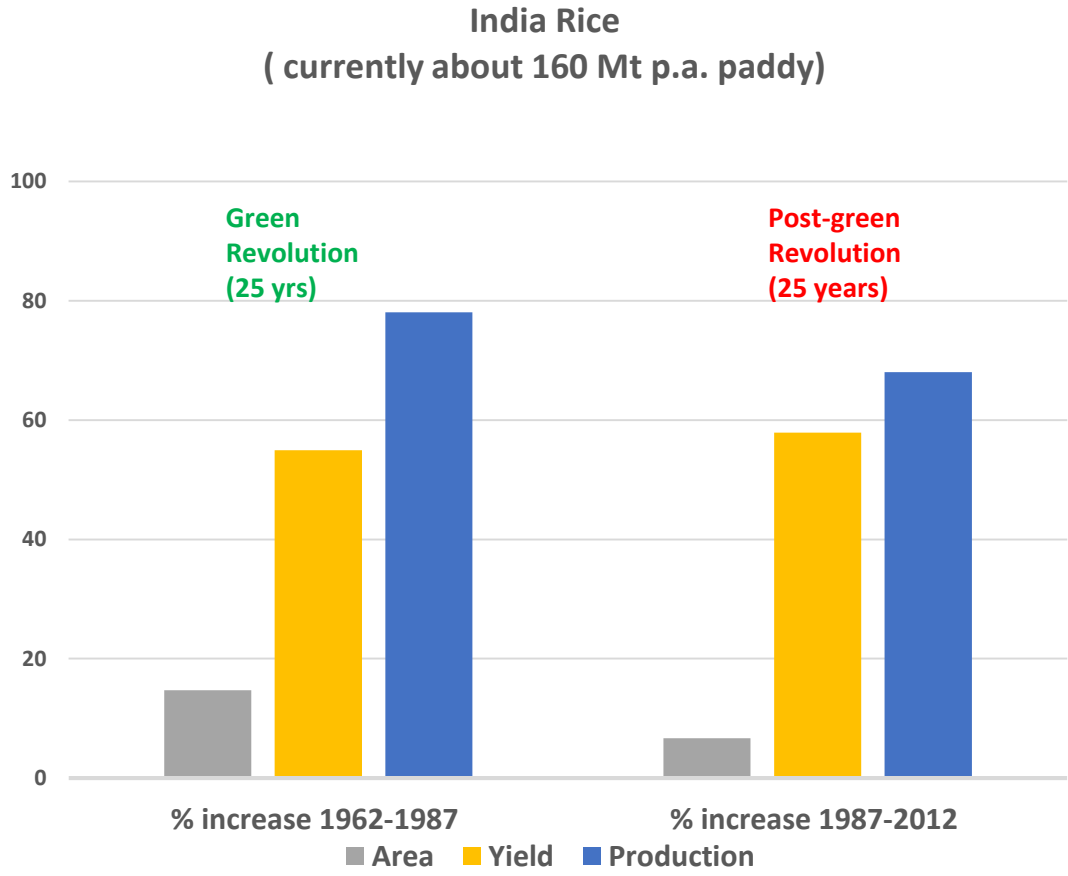
CHAMPION FARMERS

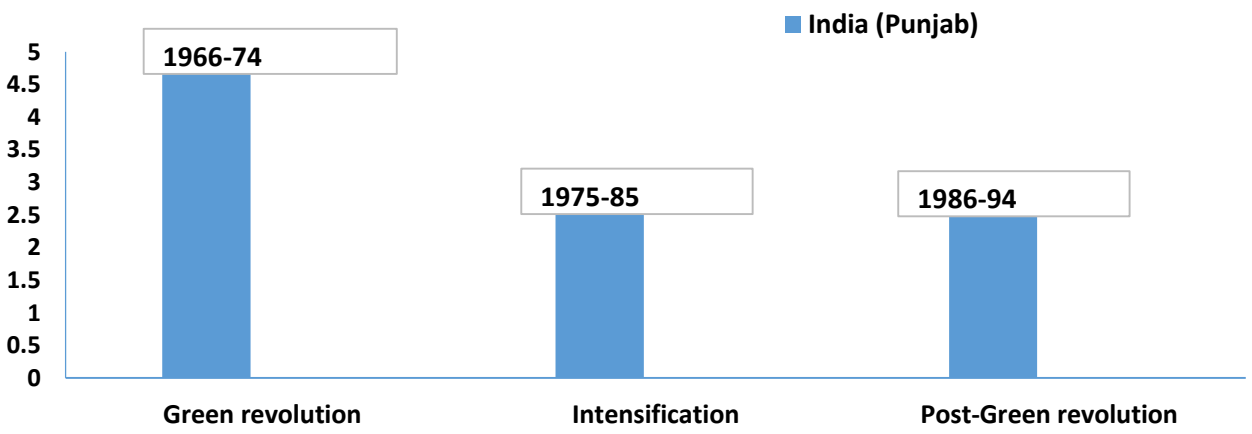




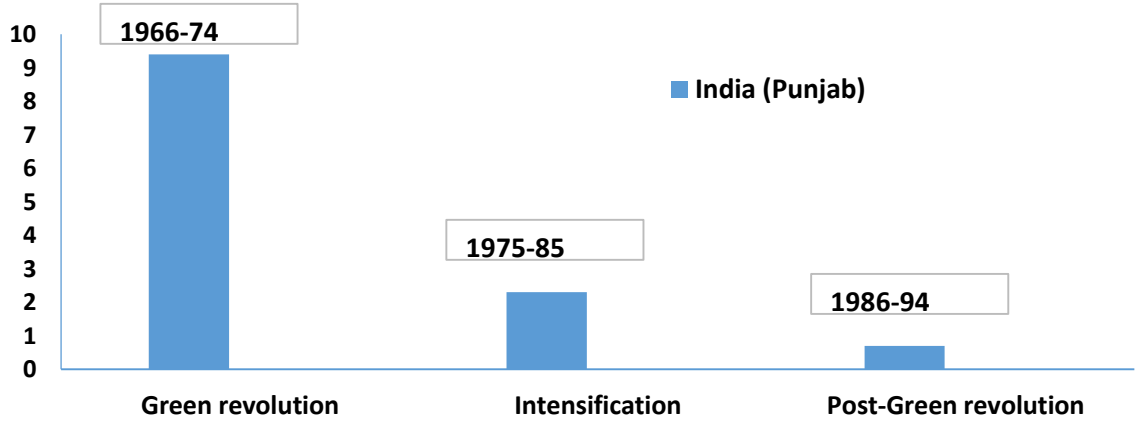
Source FAOSTAT retrieved 8 Sept 16

Post- green revolution phase in Punjab, India, the heart of the green revolution, but decreasing relative yield growth

Yield perfomance (% growth p.a.) in wheat



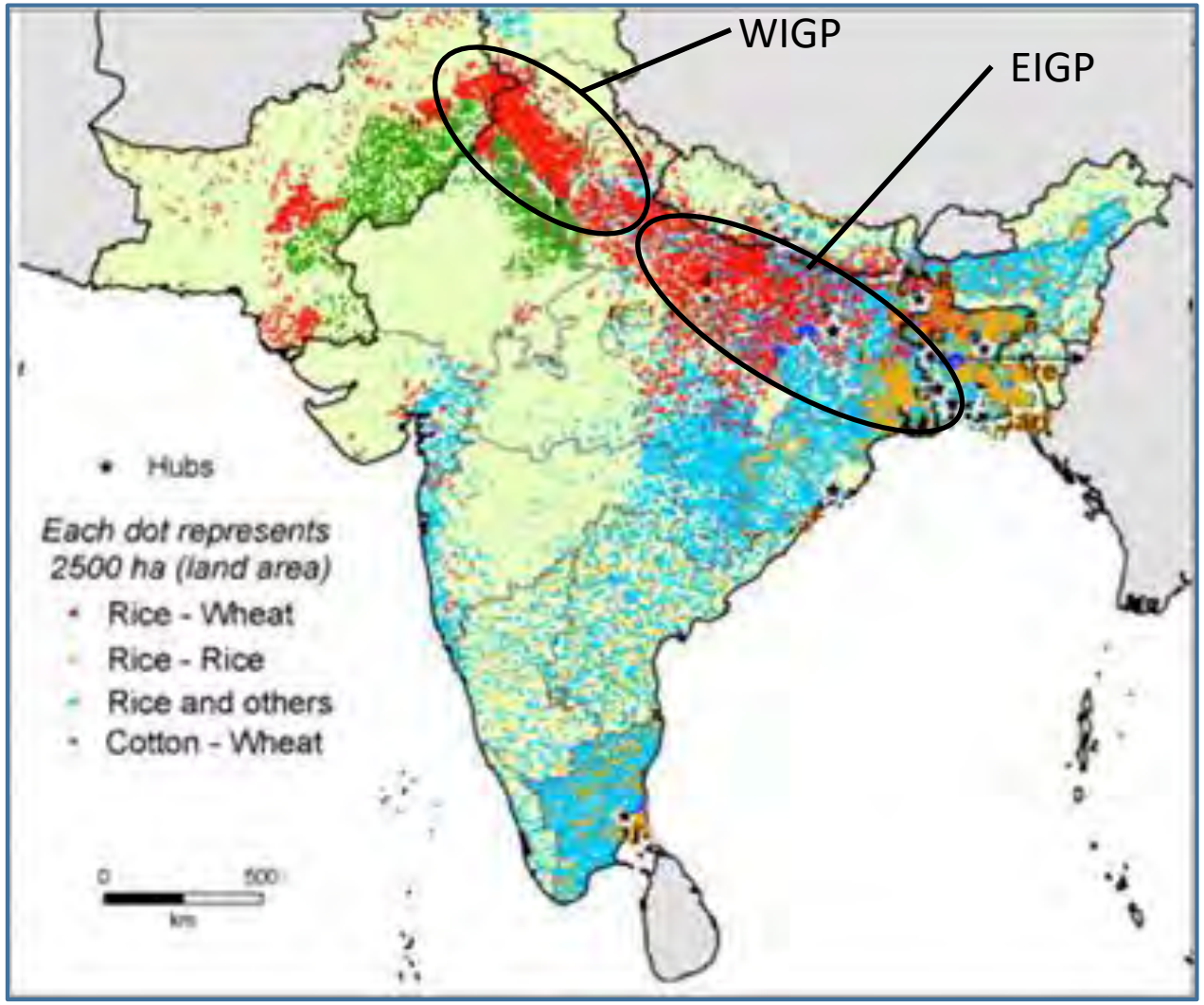
Yield perfomance (% growth p.a.) in rice



Source Murgai et al (2001)

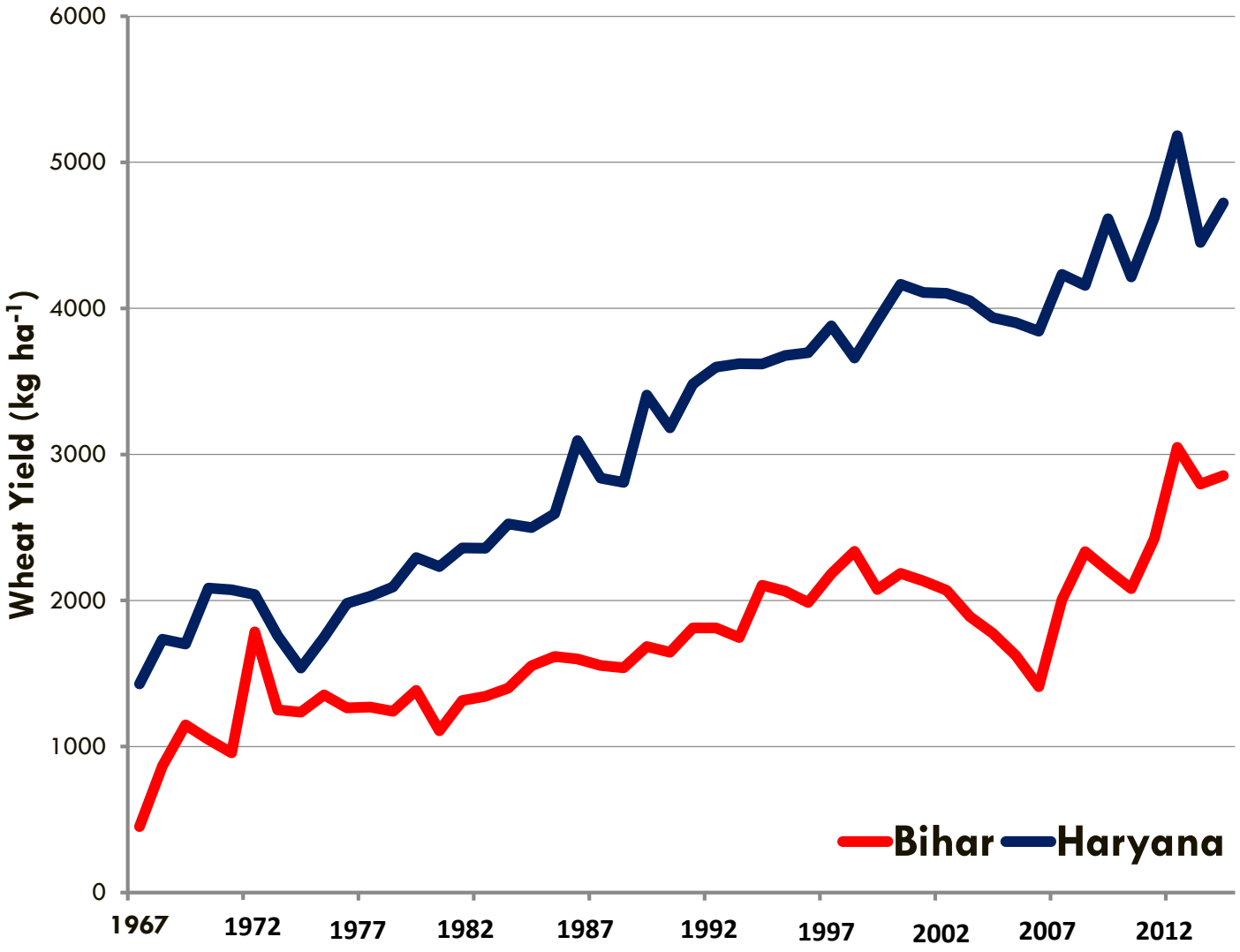
Catalysing change with small and medium farmers of South Asia

- Most poor people are in rural areas (800 M).
- High proportion of non-farm household.
- The median annual wage of a farmers is only US $ 290 which is approximately 2 months minimum wage of a worker in Delhi- The Economist 30th April 2016
- Situational Assessment of Agricultural Household show average income from farming is US $ 59/month
- Rice-wheat cropping system (red dots) is the heart of agriculture in South Asia.



WIGP – Western Indo-Gangetic Plains
EIGP – Eastern Indo-Gangetic Plains

Wheat yield for two representative states, Haryana (WIGP) and Bihar (EIGP)

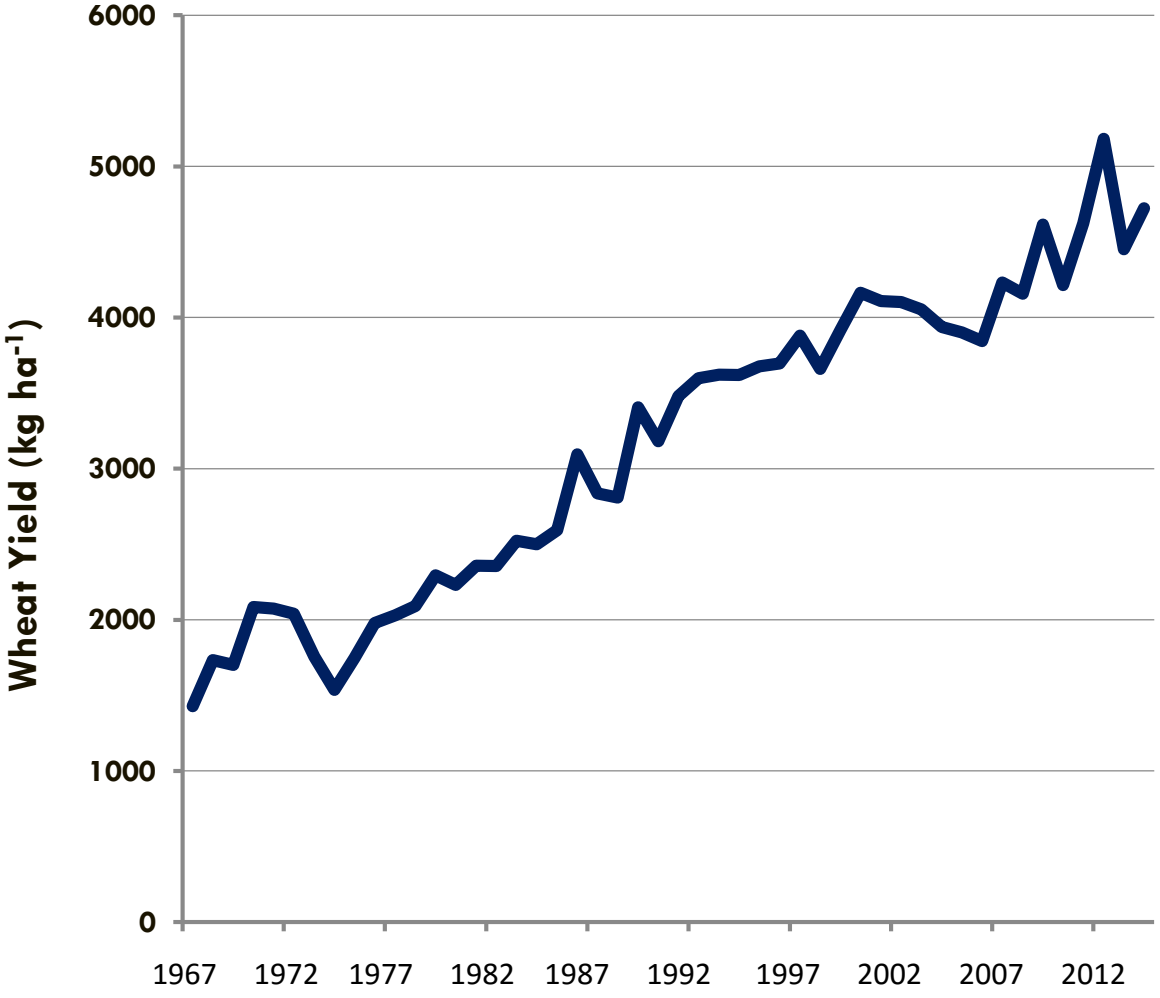


Green revolution wheat breeders in Haryana, late 1960s

Major differences between regions:

- Climate: warmer and wetter in EIGP, more floods (but terminal heat common)
- Higher population density, greater poverty, smaller farms
- Poorer infrastructure: roads, markets, irrigation, credit

WIGP (Haryana) continue to perform better through agronomic management



- Rice-wheat, millet-wheat, cotton-wheat
- Mod. operational land holding (approx. 4 ha)
- Birth place of green revolution,

Changes since then:

- Better nutrient management
- Zero till borne of necessity
- Management of rice straw
- Earlier sowing
- Land levelling
- Diversification?
- Breeding - slower yield progress but rust held at bay

75% wheat in Haryana is surplus

Improving Soil health: Replacing general recommendations with condition specific approaches

- How to increase agronomic efficiencies in soil fertility management
- Decision tools, green seeker, nutrient expert (NE), Crop manager (CM)
- Knowledge dissemination approaches
- Soil health cards
- Digital soil mapping technology

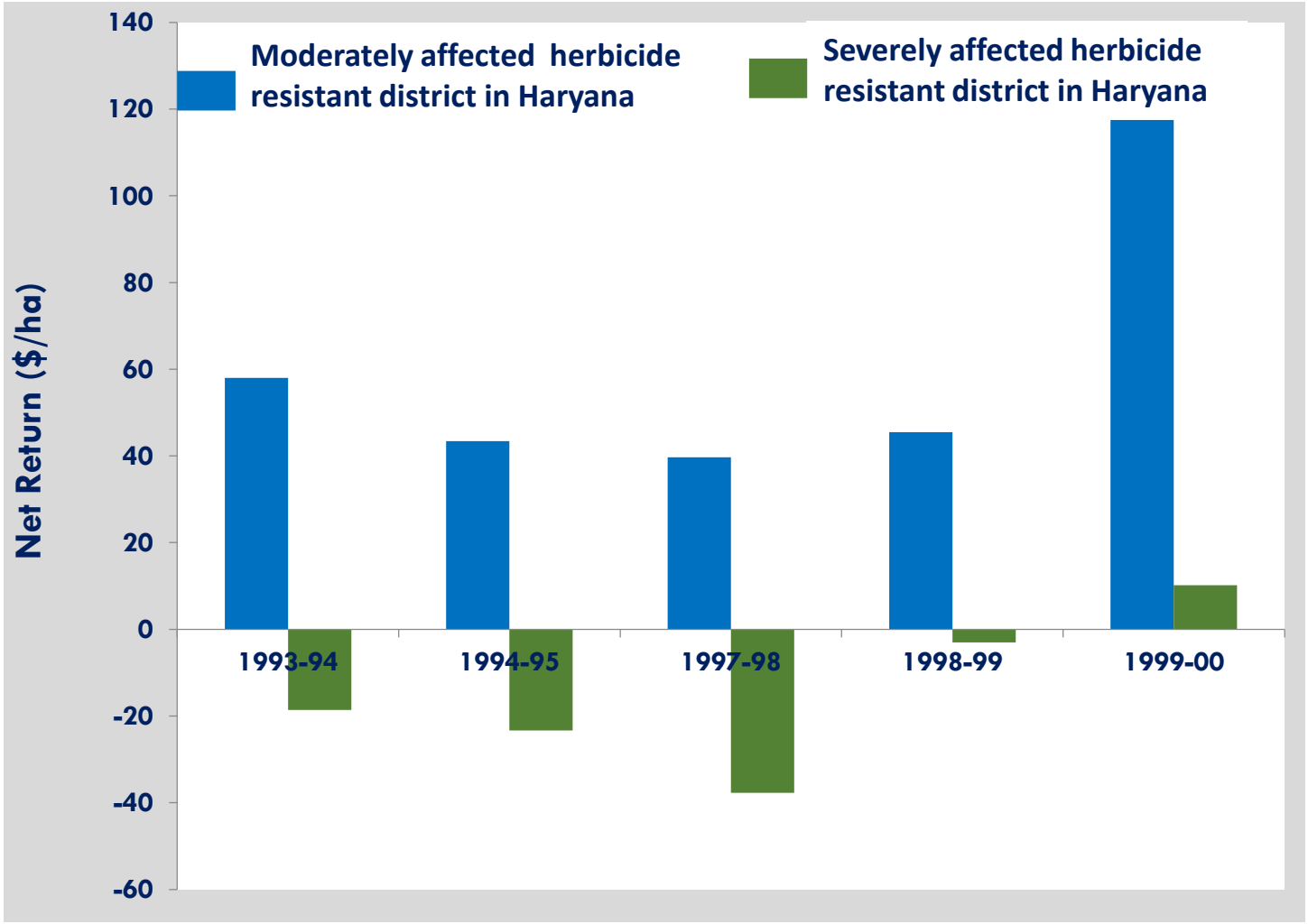
On-farm trials Haryana (N= 33)

Treatment	Yield	Δ Yield from FP	N	P_2O_5	K_2O
FP (Farmer practice)	3.43 c	0 c	130 a	65 a	22 c
SR (State recommendation)	3.55 c	0.11 c	88 c	40 c	26 c
RWCM	3.74 b	0.30 b	109 b	55 b	35 b
RWCM+K	3.91 a	0.48 a	109 b	55 b	65 a

Δ in Grain yield in RWCM compared to FP: + 0.30 to 0.50 t/ha

Δ in fertilizer: -20 kg N/ha; -10 kg P_2O_5/ha; +13 to 43 kg K_2O/ha

Herbicide resistance management launched through ACIAR project (Phalaris minor resistant to isoproturon)



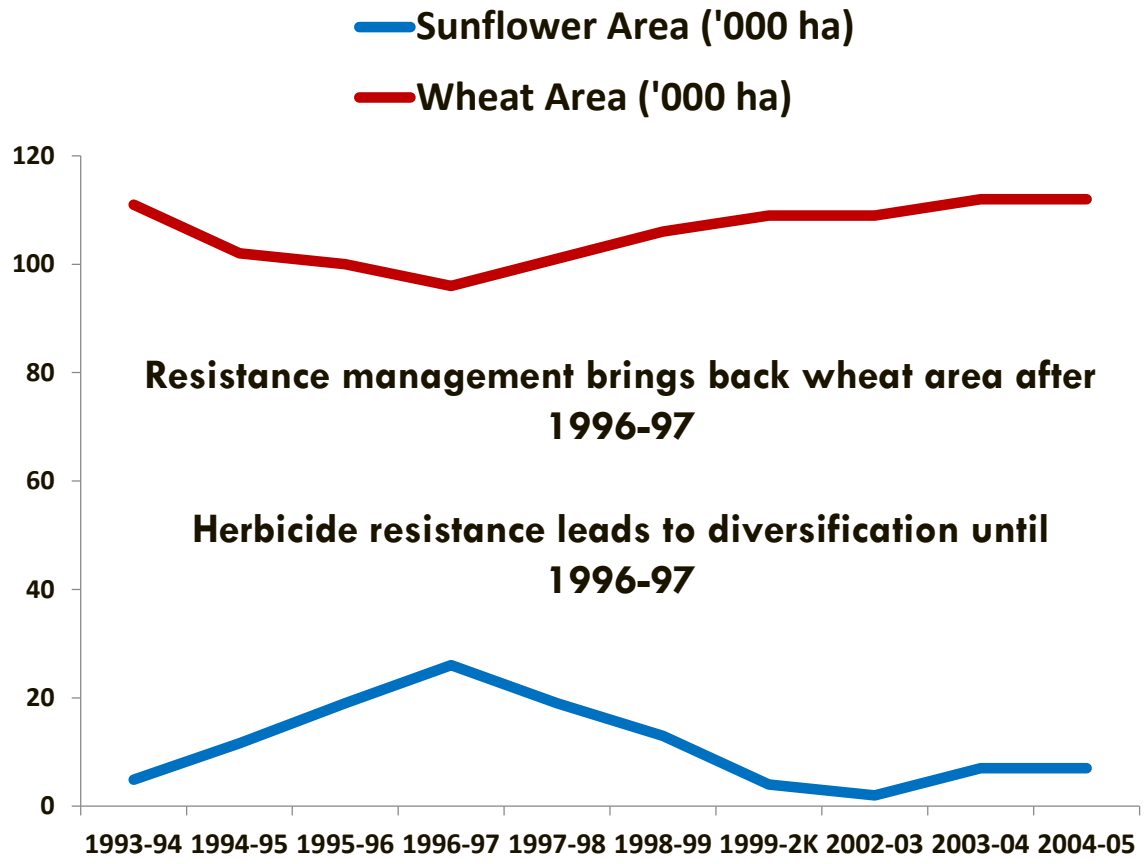
Inverted “T”cross slot seed drill from New Zealand. In1982, up to 1992 no impact, why?

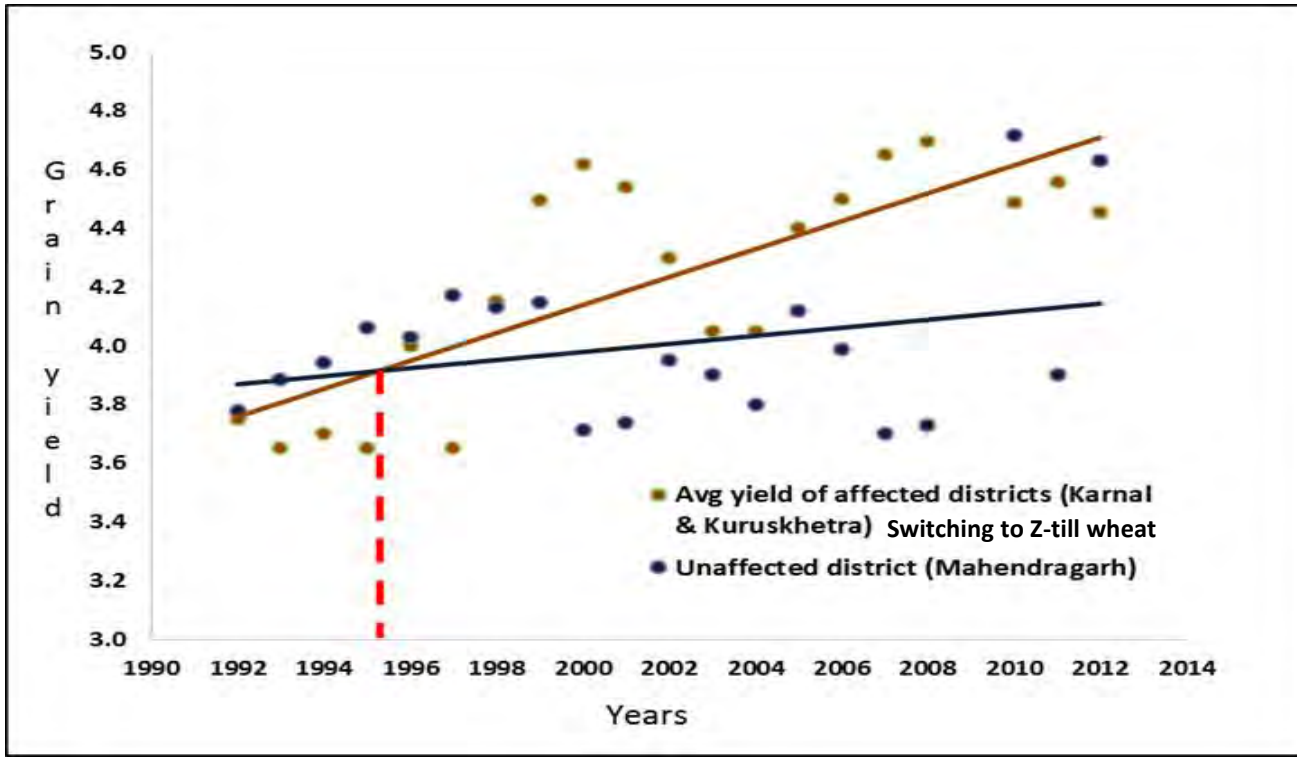
Inverted “T” opener

ZT- at dead end till 1993. Factored in five years yield losses due to resistant *Phalaris*. ZT reduced *Phalaris* population to a sustainable level. Provided a paradigm shift leading to its evolution in WIGP.

A major reform after Green Revolution

It all stacks-up - impact on diversification and wheat productivity in weedy district in the state of Haryana – WIGP (Source: Statistical abstract of Haryana)





Summary of benefits and costs (net present value[a] to 2030)

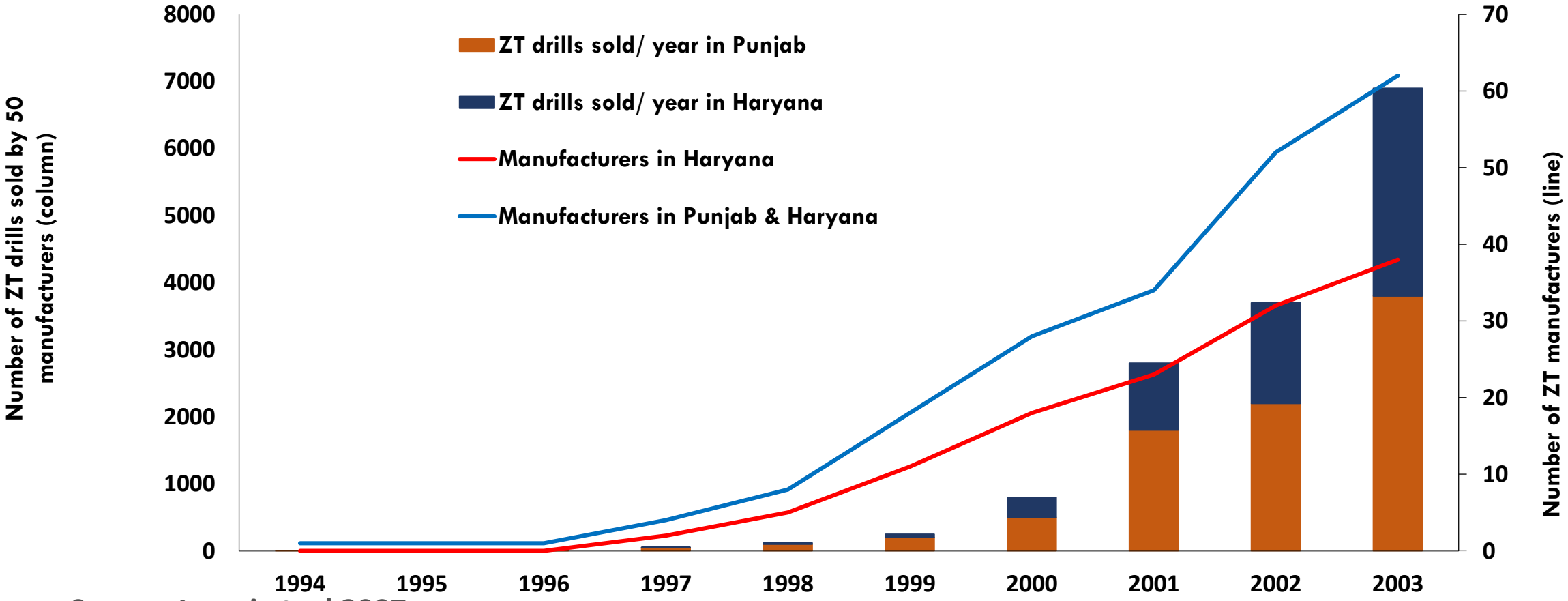
(Source: Vincent and Quirke, 2002, ACIAR Project 1998-2003, cost 1.1 million A$, ex-ante based on 0.35 M ha Z-till for 30 years)

Producer benefits[b]	**Net present value**	
	A$m	(%)
Prevention of future decline in yield through re-emergence of herbicide resistance	103	5.7
Reduction in herbicide outlays	175	9.7
Reduction in tillage costs	950	52.5
Avoidance of ling-term yield decline through degradation	24	1.3
Yield premium due to early sowing and closer spacing	557	30.8
Total producer benefit (world prices)	1809	100.0
Net gain to India	**1809**	

[a]Discount rate of 5%, *[b]Increase in gross margin valued at world prices*

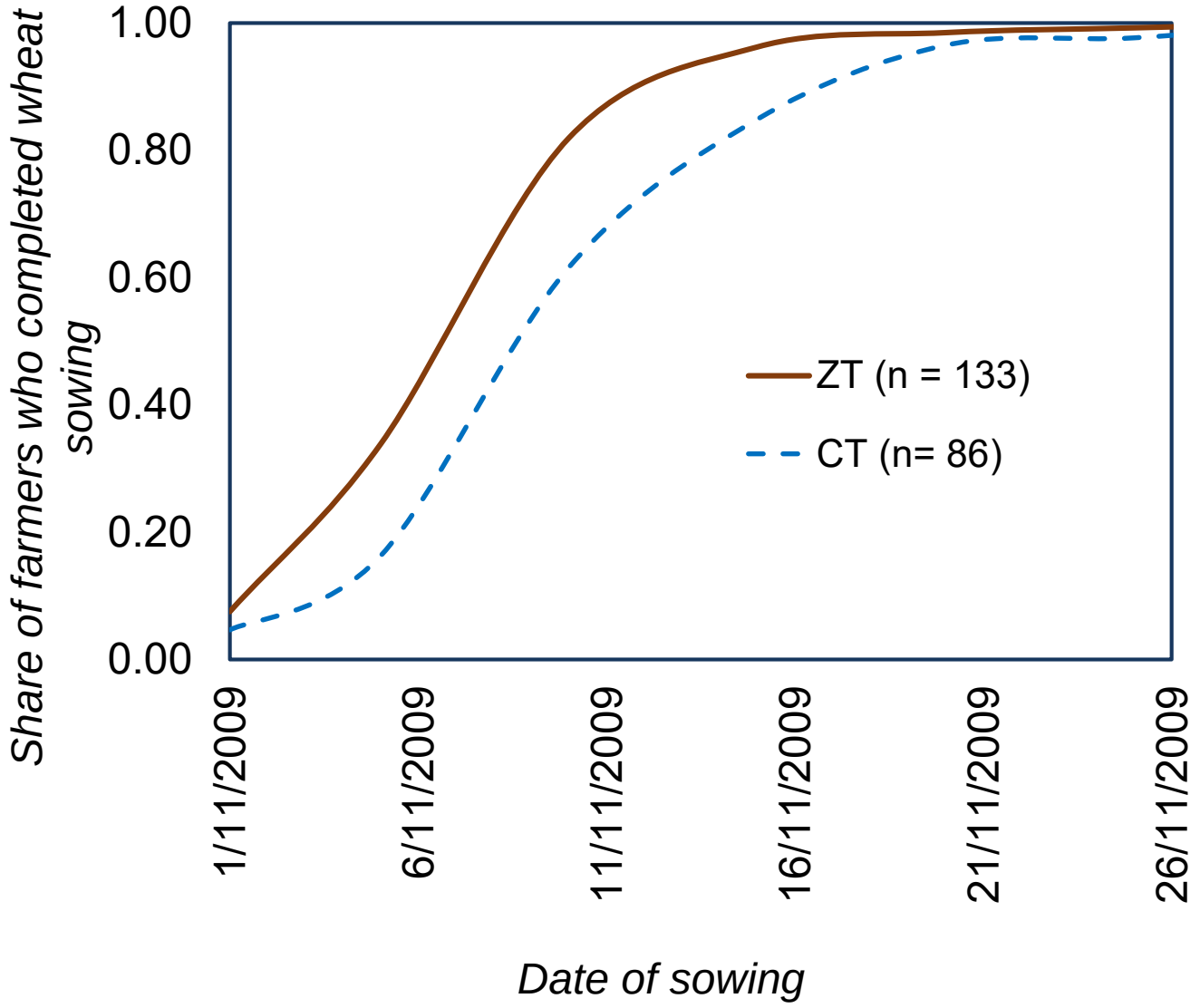
Evolution of zero tillage created new small scale industry in Haryana & Punjab

(n=50), 1994-2003



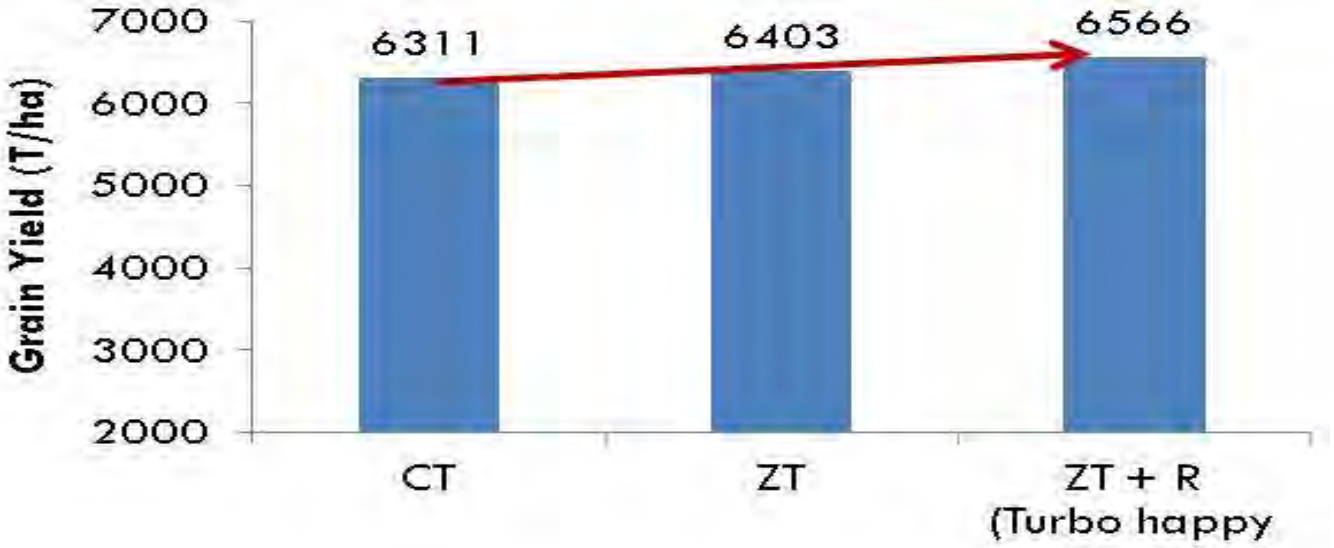
Source: Laxmi et. al 2007

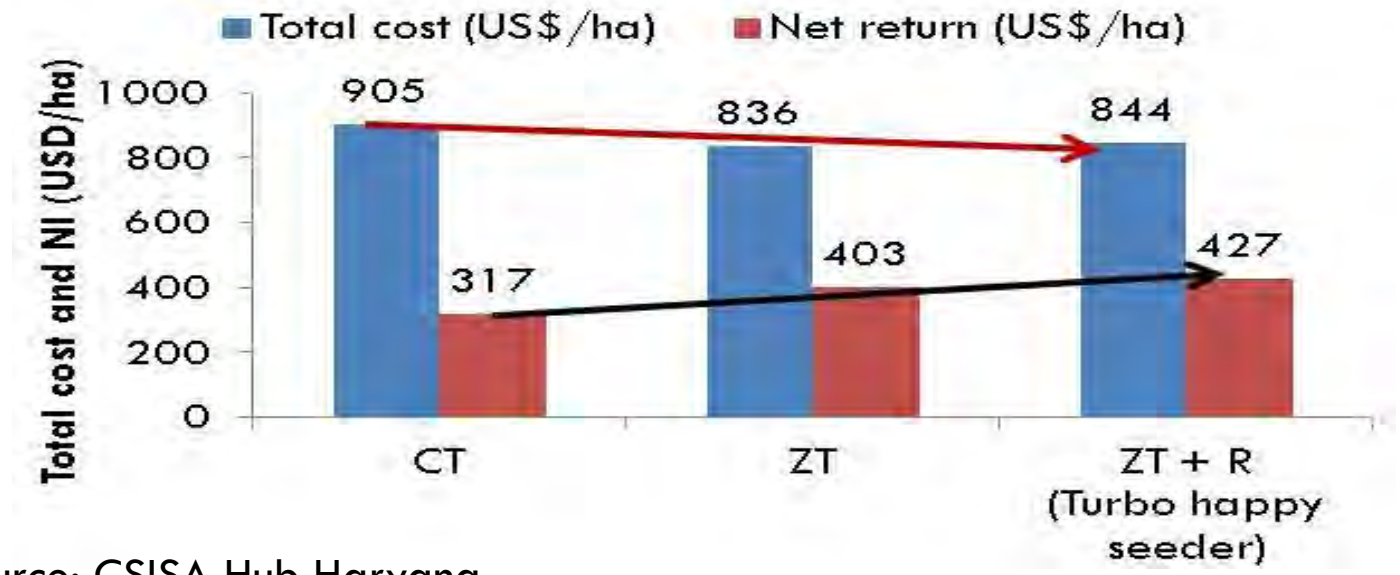
Cumulative distribution of sample farmers according to date of wheat sowing (survey Haryana 2011)



Source: Krishna and Veettil (2014)

Bright future of rice residue retention to mitigate climate variability and heat stress (2012-13)

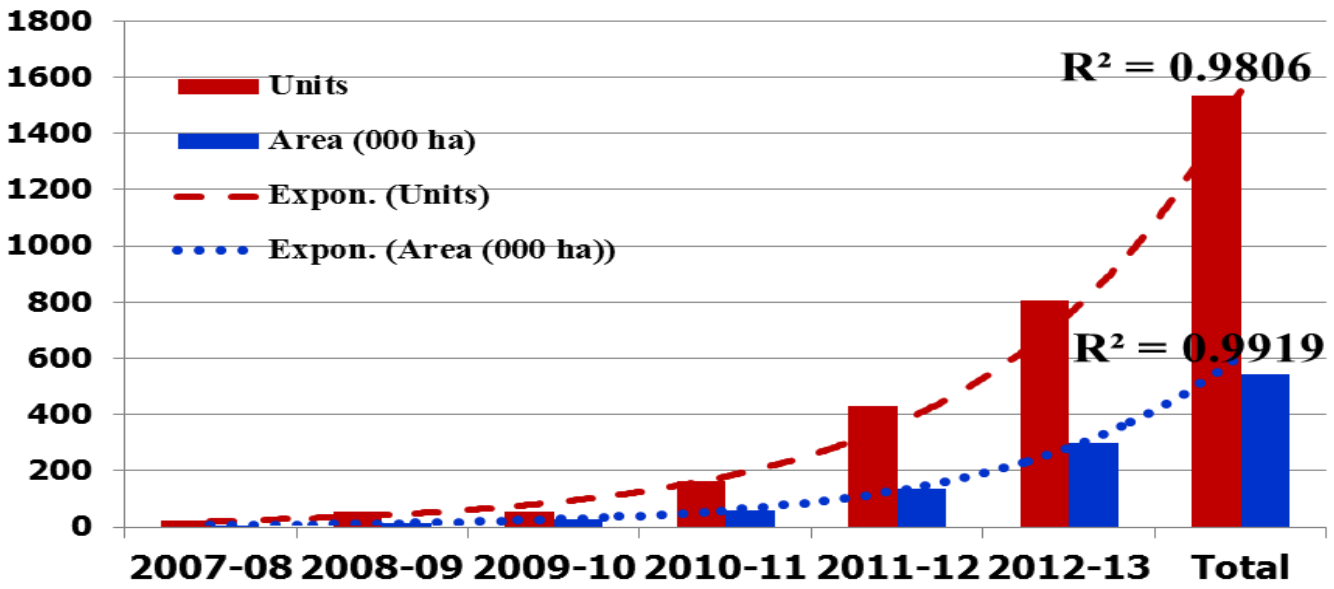




Source: CSISA Hub Haryana

Laser Assisted Precision Land Leveling - scale of adoption

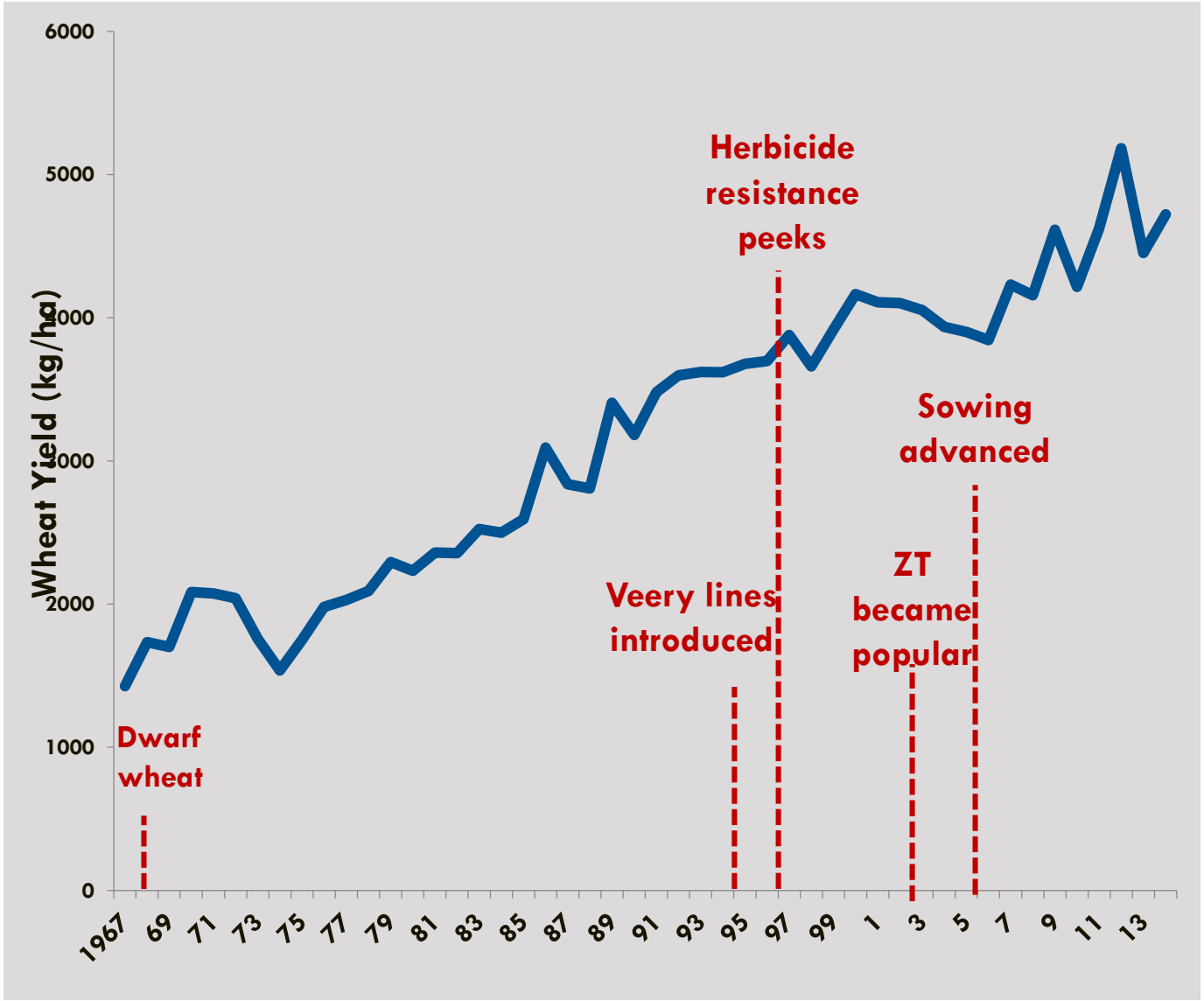
Haryana



- Estimated amount of irrigation water saving- 1 bn m^3 yr^{-1}
- Yield gains in rice is 175000 t, wheat 155000 t, RW system-0.33 Mt yr^{-1}
- GHG mitigation 163,600 MT of CO_2e/yr

Sources: CIMMYT-CCAFS Impact Study (2014)
State Department of Agri, GoH (2014)

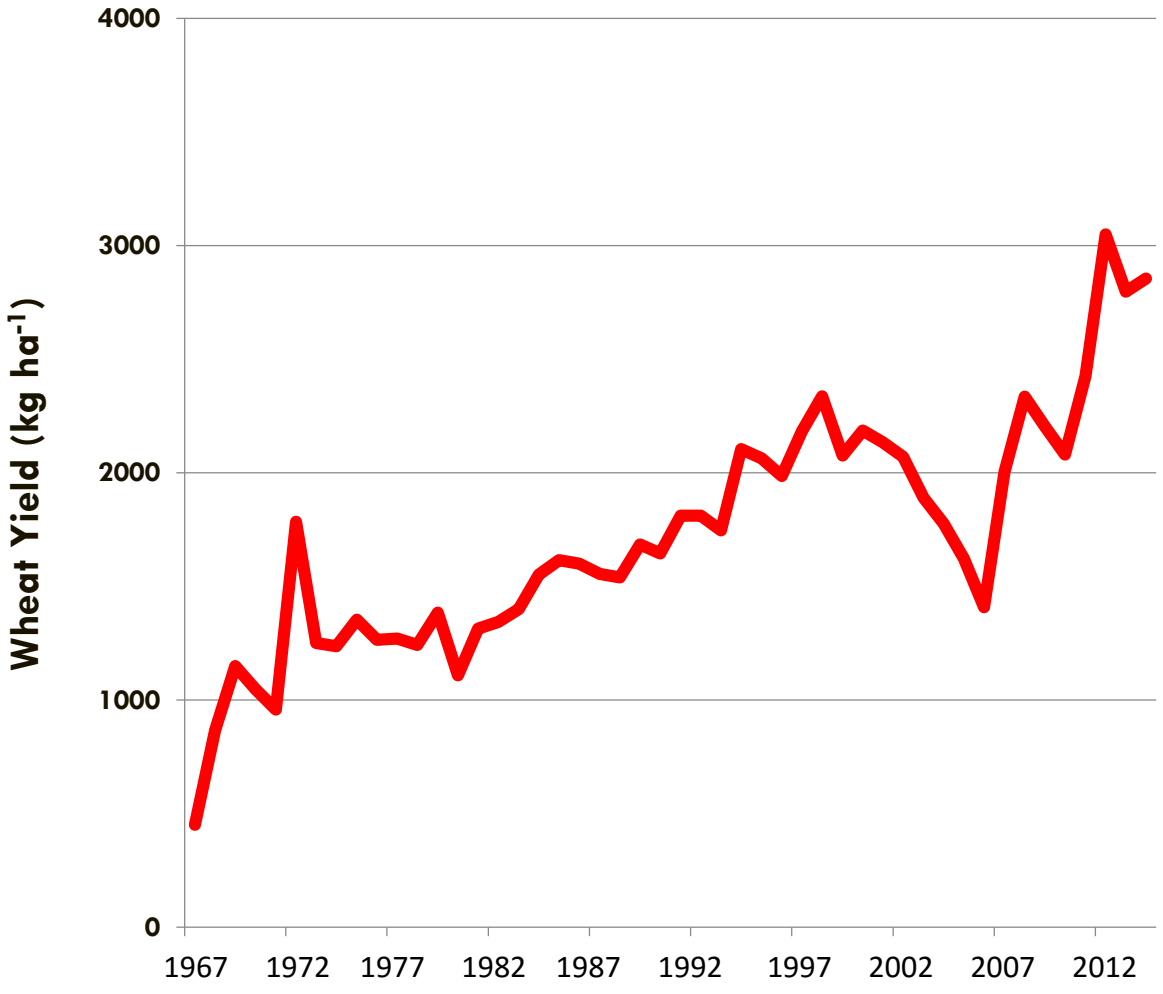
Haryana and WIGP Lessons learnt : How to translate the power of agronomic management?



The future for further yield increase and better sustainability:

- Dependence on support prices and subsidies
- Incomplete adoption of Z-till
- Cost of labour
- Lack of diversity
- New weeds/Resistance
- Declining water table
- Nitrate pollution
- Soil Health, SOC
- Global Warming

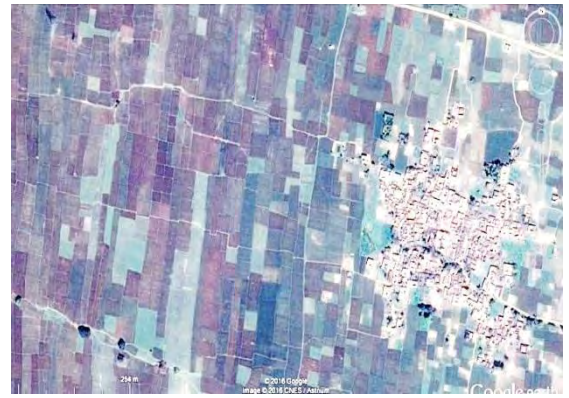
EIGP (Bihar): Focus on providing solutions to realize its true potential



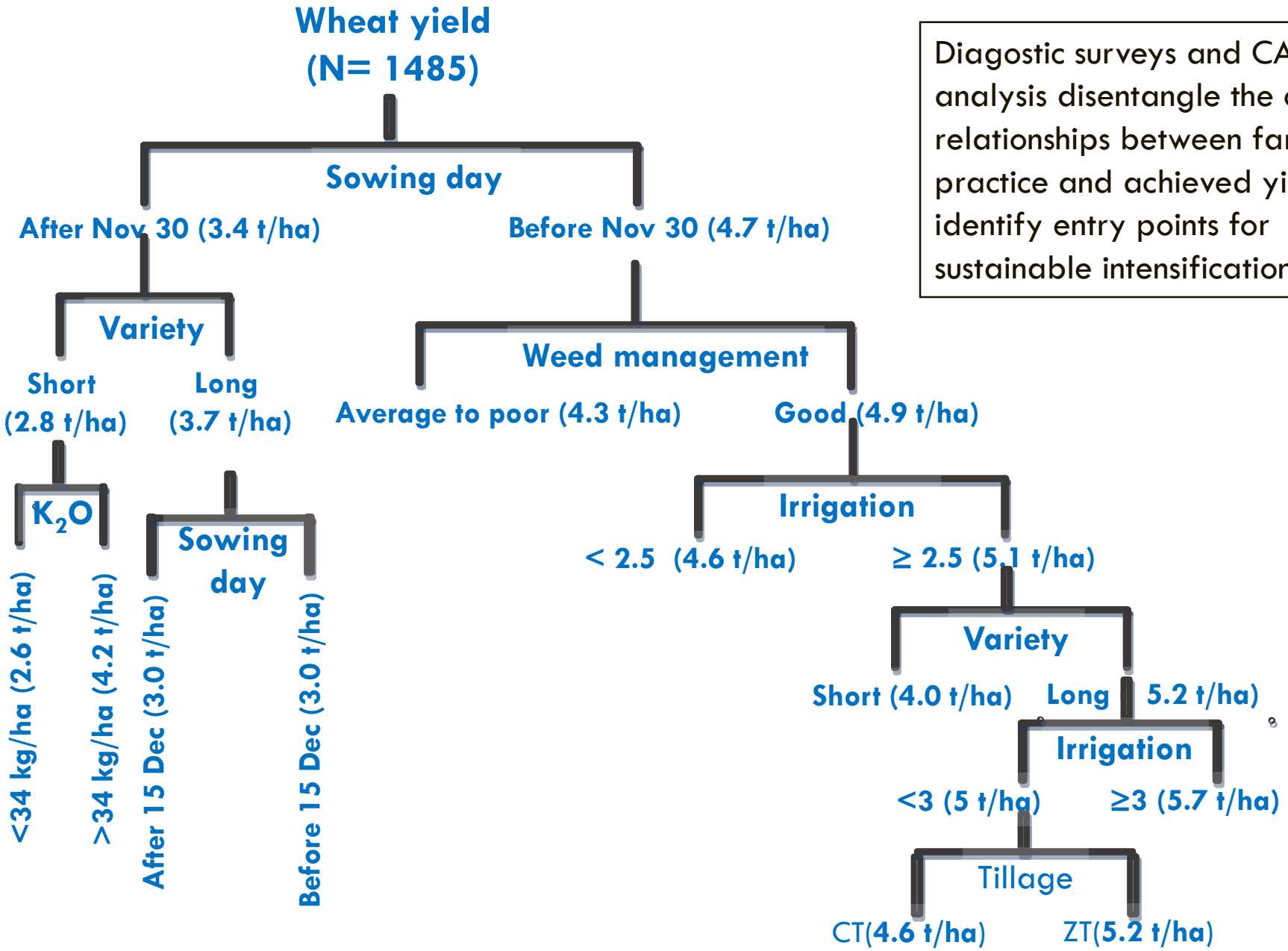
- Rice-wheat and winter fallow land,
- Tiny farms (0.3 ha)
- Poorer infrastructure, markets, higher costs
- Less progress during and after green revolution years

Changes since then

- Greater R, D and E focus
- Improved seed replacement rates
- Earlier seeding and zero till wheat
- Hybrid rice
- Winter maize
- Double, triple cropping.



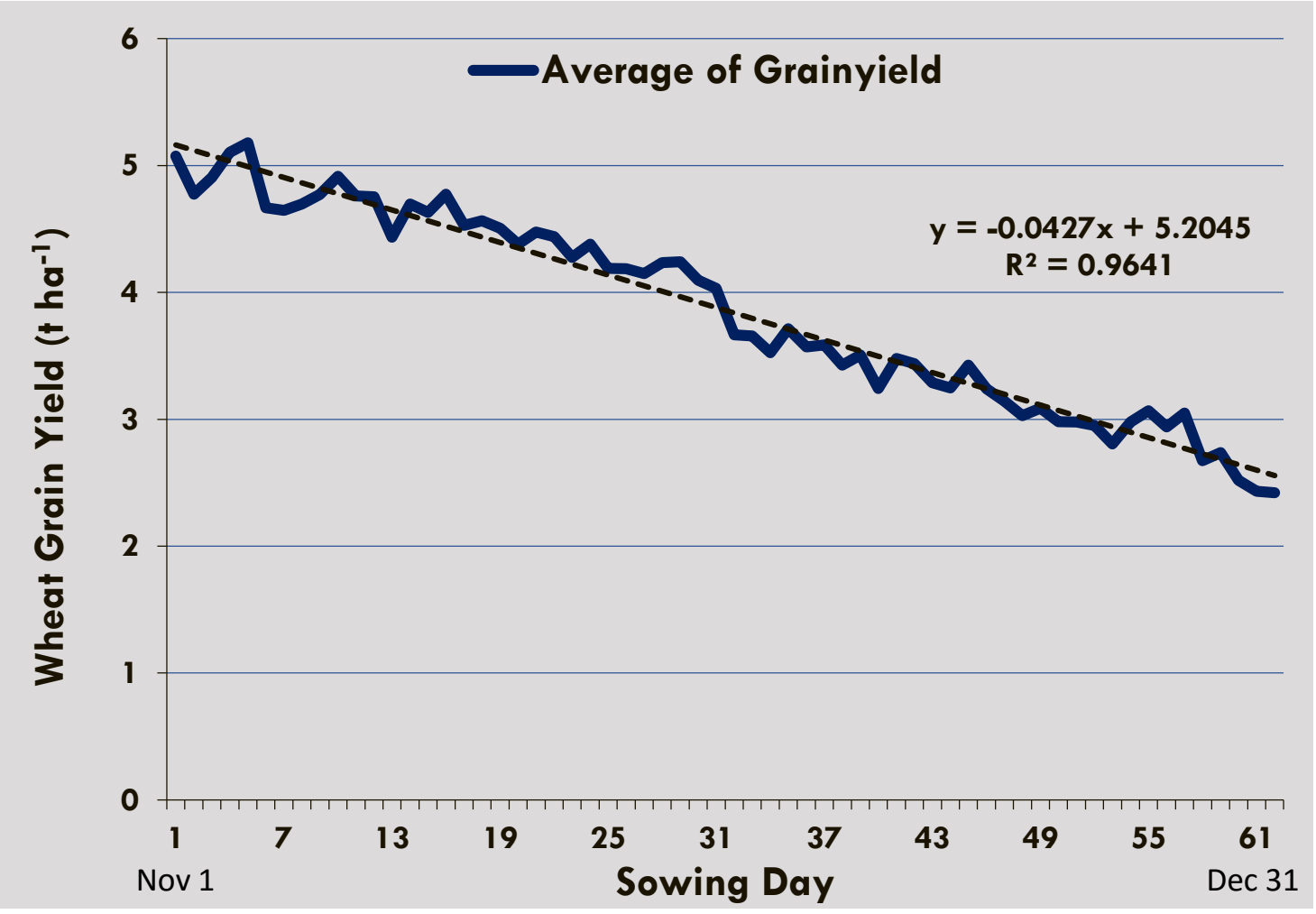
Bottom-up R, D and E: Diagnostic on-farm data mining techniques: learning from landscapes, on farm crop cuts EIGP (2012 to 2014)



Diagostic surveys and CART analysis disentangle the complex relationships between farmer practice and achieved yields, and identify entry points for sustainable intensification.

Early wheat sowing is critical to avoid the terminal heat: Grain yield of wheat in EIGP

SYSTEMS-BASED APPROACHES ARE ESSENTIAL

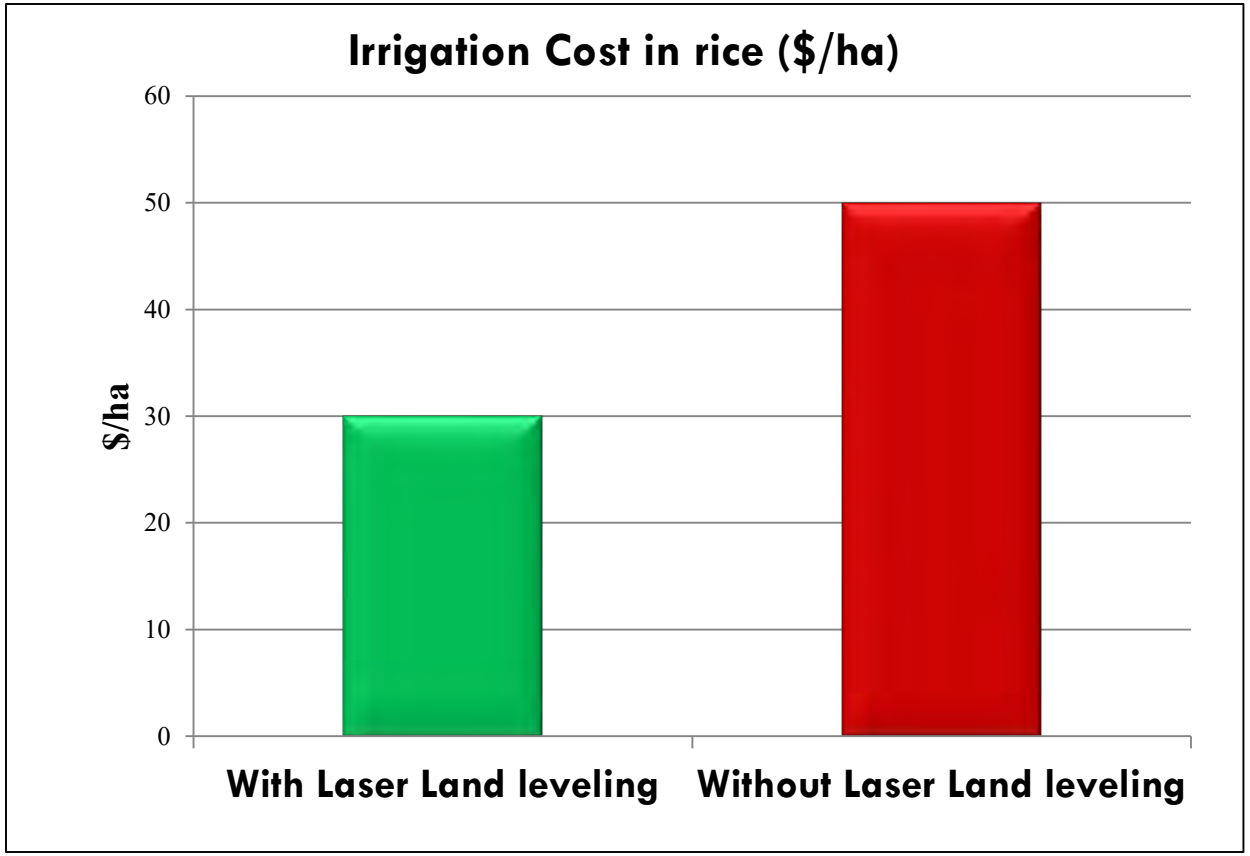


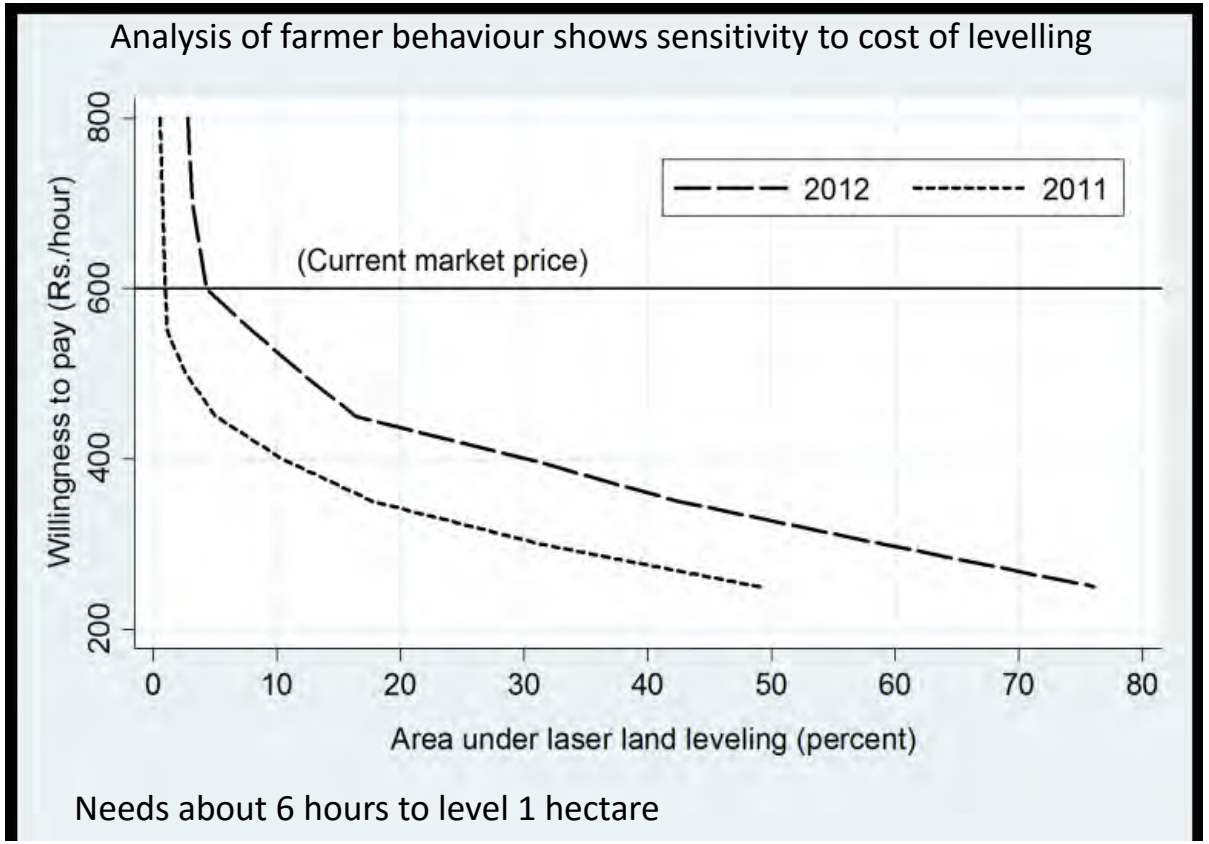
Based on Crop cut data – 6809 samples in 7 years in Bihar & eastern UP

<u>Opportunities for timely planting:</u>

- **Shorter duration rice (e.g. hybrids)**
- **Early rice establishment**
- **Post harvest mechanization for rice**
- **Zero-tillage for wheat**
- **Land configuration and drainage**
- **And calls for varieties adapted to early sowing!!**

Laser land leveling – scale, scalability and speed in EIGP





- Diesel pump based irrigation in EIGP is costly.

(Lybbert et al. 2014)

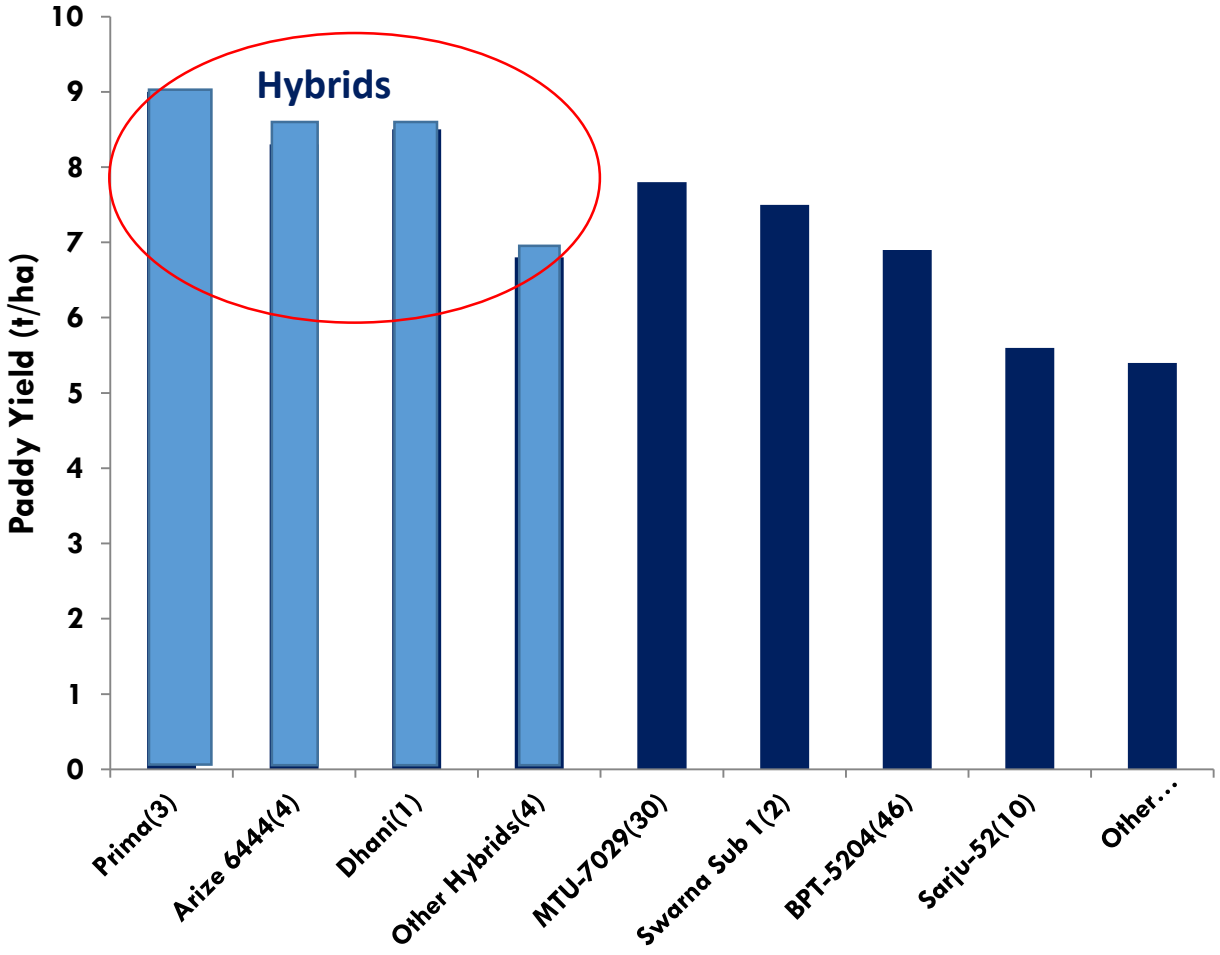
Crop establishment method and rice-wheat system productivity (Bihar, Avg of 3 years: 2012-15)

Treatments		Rice		Wheat		System	
Tillage and CE method							
	PTR fb CTW	6552	a	4254	c	10806	b
	PTR fb ZTW	6552	a	4670	b	11216	ab
	MTNPR fb ZTW	6931	a	4913	a	11845	a
	DSR fb ZTW	5960	b	5149	a	11110	ab
	SRI fb SWI	6706	a	4622	b	11328	ab

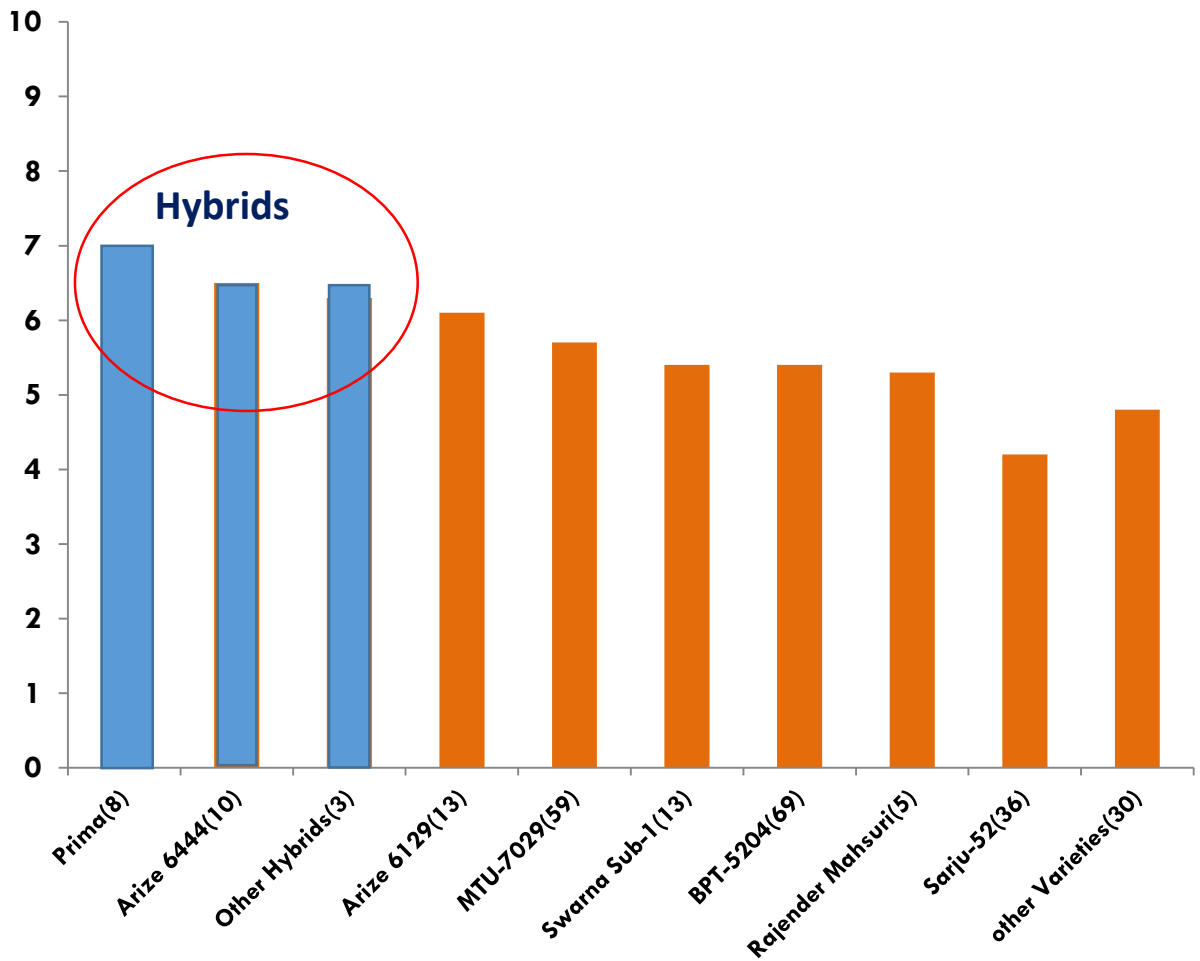
- PTR- Puddled transplanted rice
- CTW- Conventional till wheat
- ZTW- Zero till wheat
- MTNPR- Machine transplanted non puddled rice
- DSR- Direct seeded rice
- SRI- System of rice intensification
- SWI- System of rice-wheat intensification

Performance of rice hybrids and varieties in MTNPR and DSR in EIGP in kharif (summer)

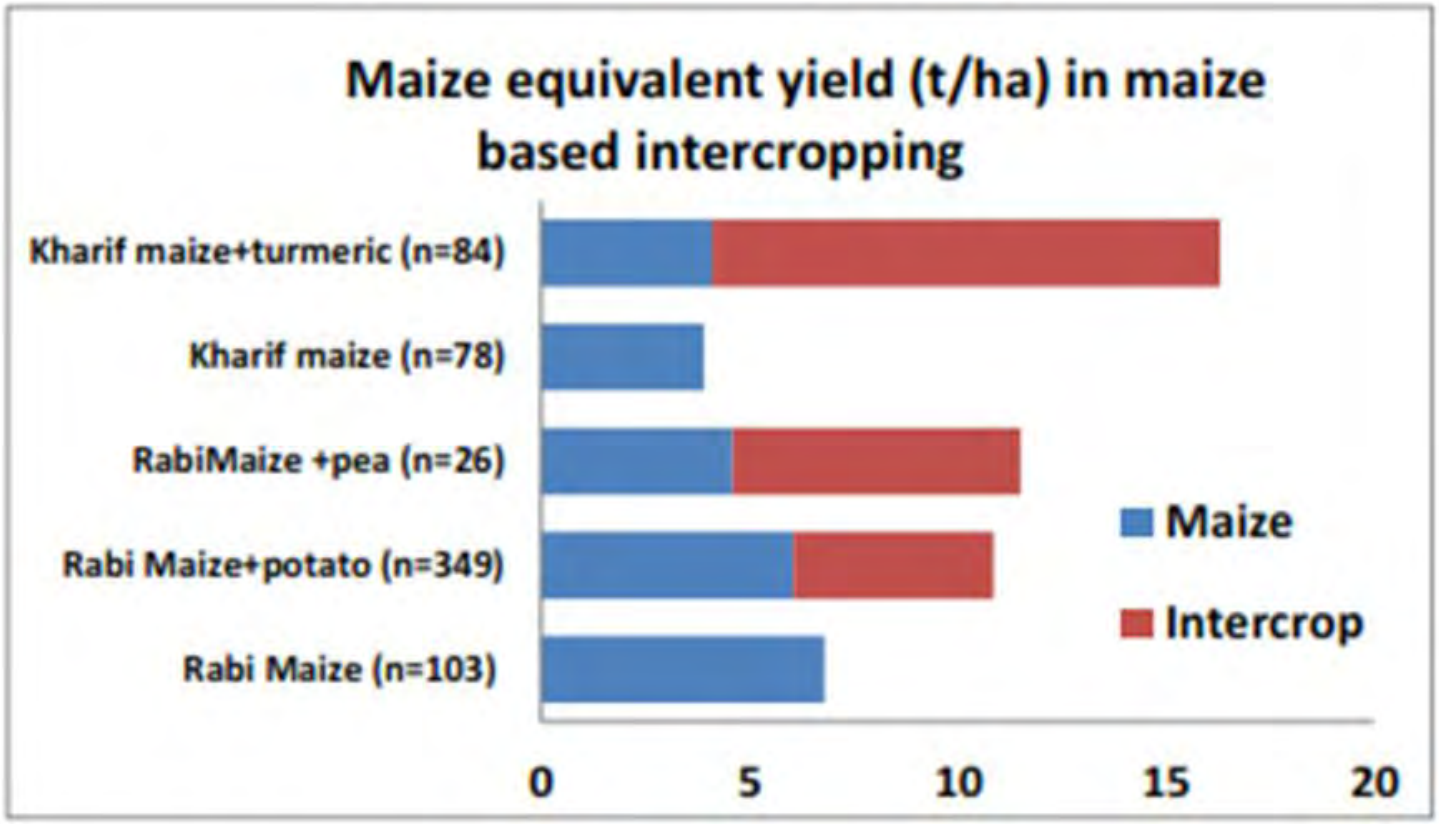
Machine transplanted non-puddled (MTNPR)

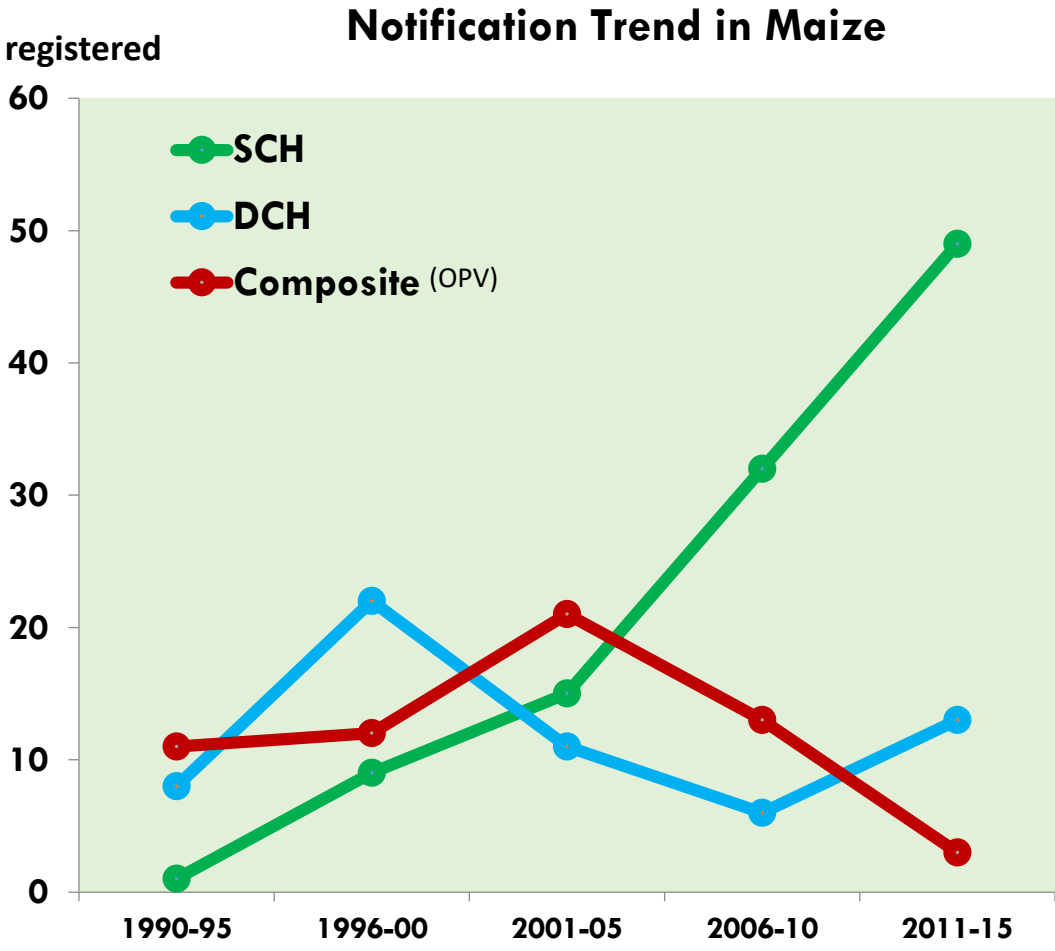


Direct seeded rice (DSR)



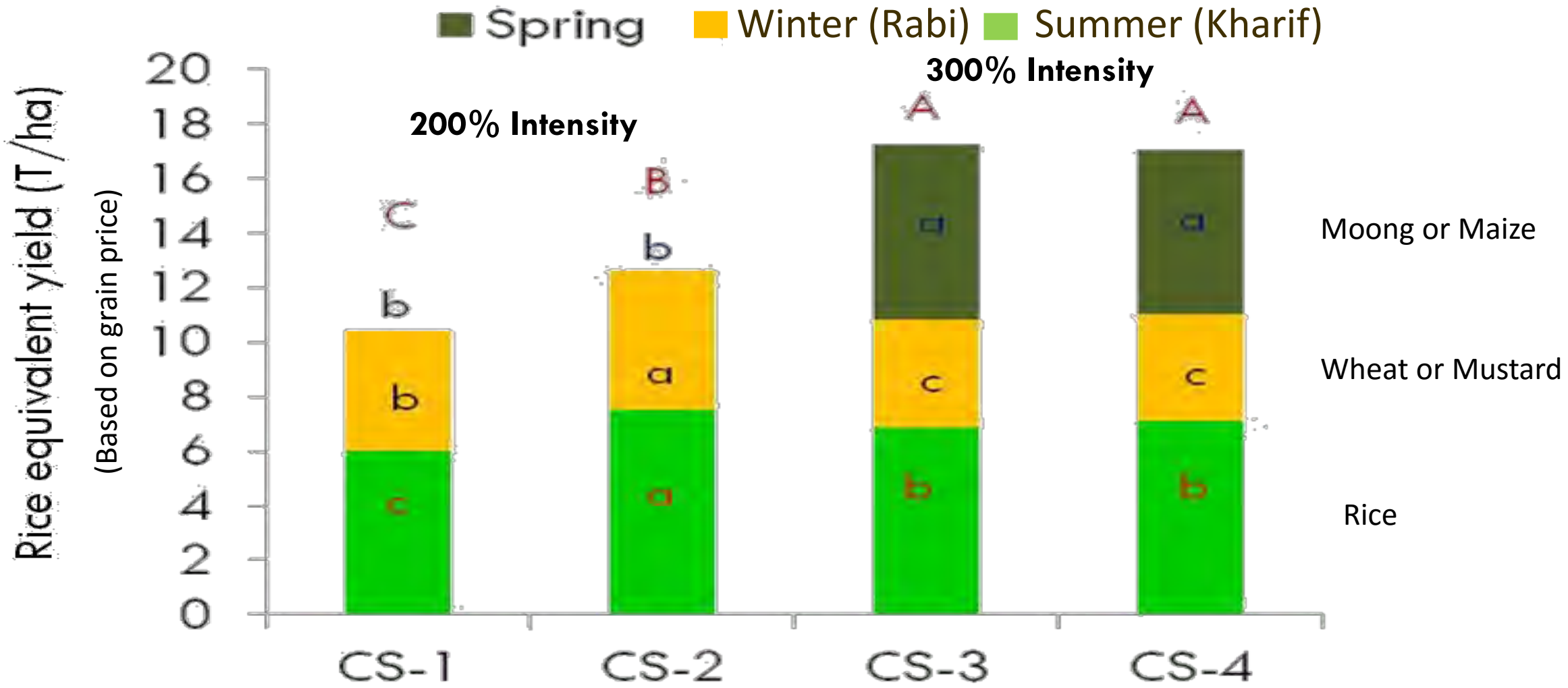
Maize: bringing diversification after evolution of single cross hybrids (SCH) in Bihar and Eastern UP, ; both summer (kharif) and winter (rabi)





Double and triple cropping systems optimization

(In collaboration with IARI, Regional station, Pusa, Samastipur, Bihar)



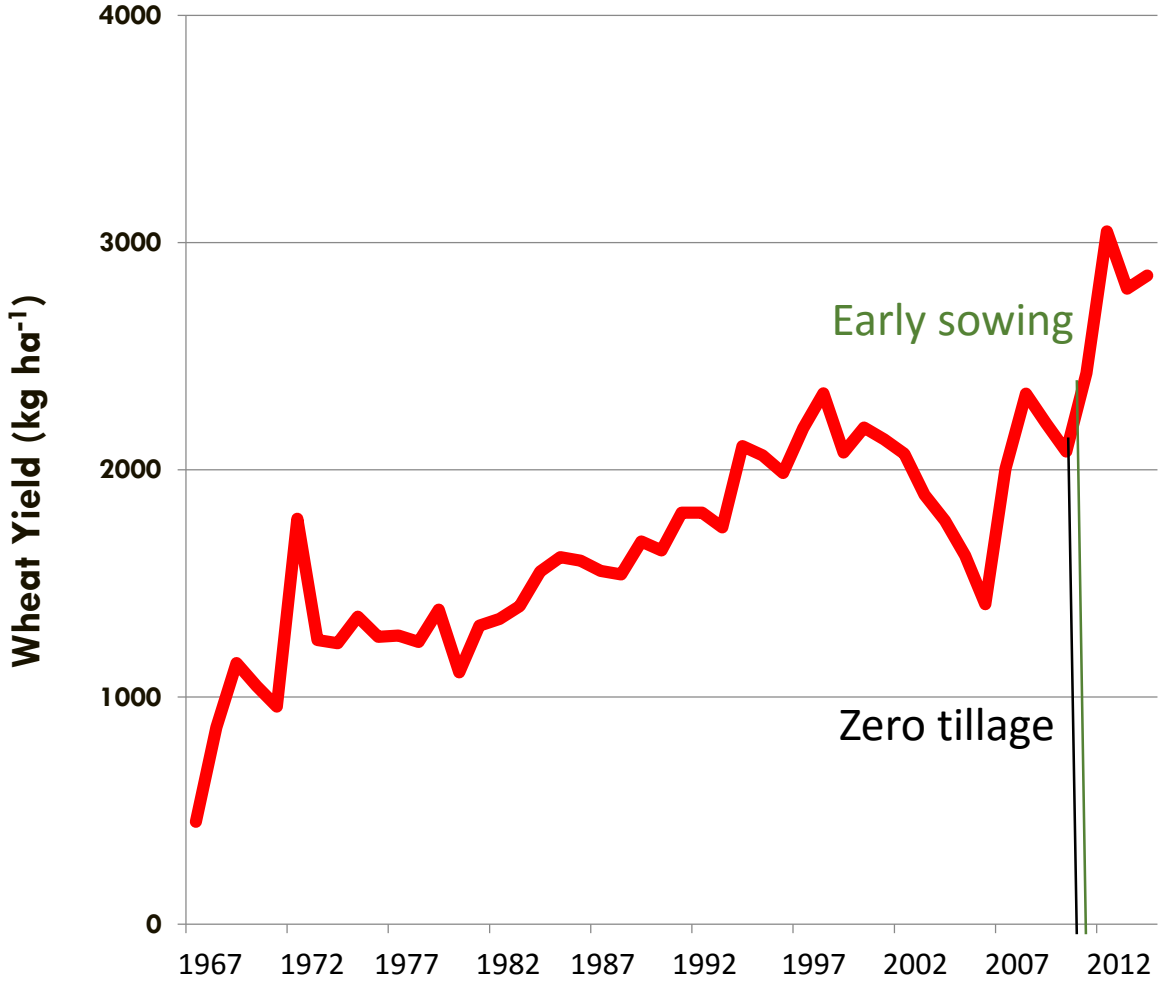
CS1: Rice (long duration inbred MTU-7029) fb wheat

CS2: Rice (Med duration hybrid Arize-6444) fb wheat

CS3: Rice (short duration hybrid Arize-6129) fb mustard fb maize

CS4: Rice (short duration hybrid Arize-6129) fb mustard fb mung

Looking ahead for a bright future through tillage reforms in EIGP



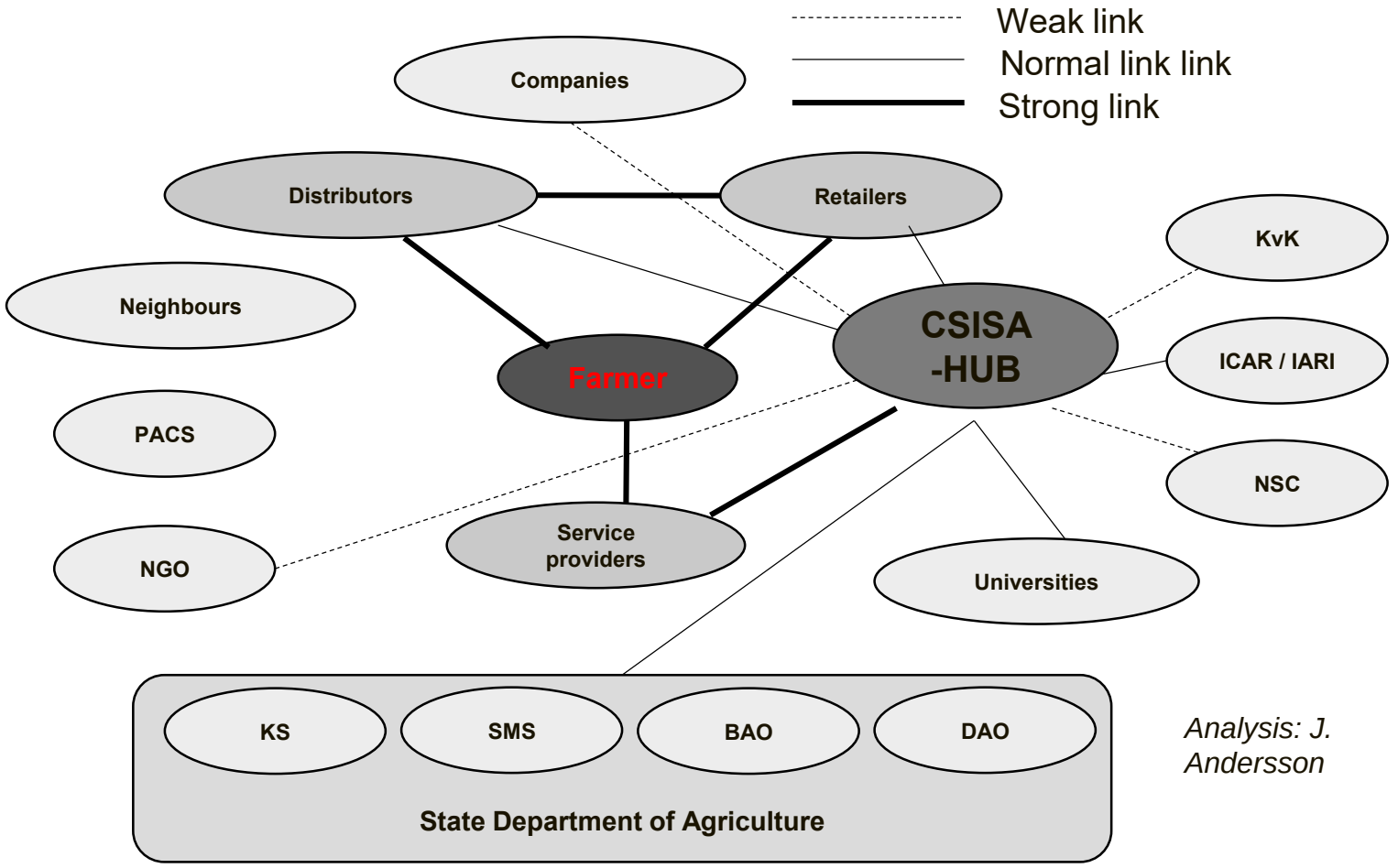
The future:

- More zero till and small machines
- More early seeding More laser levelling
- DS and hybrid rice
- Winter maize
- Triple cropping
- Breeding opportunities from agronomy, esp early seeding.

Agricultural Innovation System (AIS) – depth of engagement with all the key agents

Leveraging the agricultural innovation system (AIS)

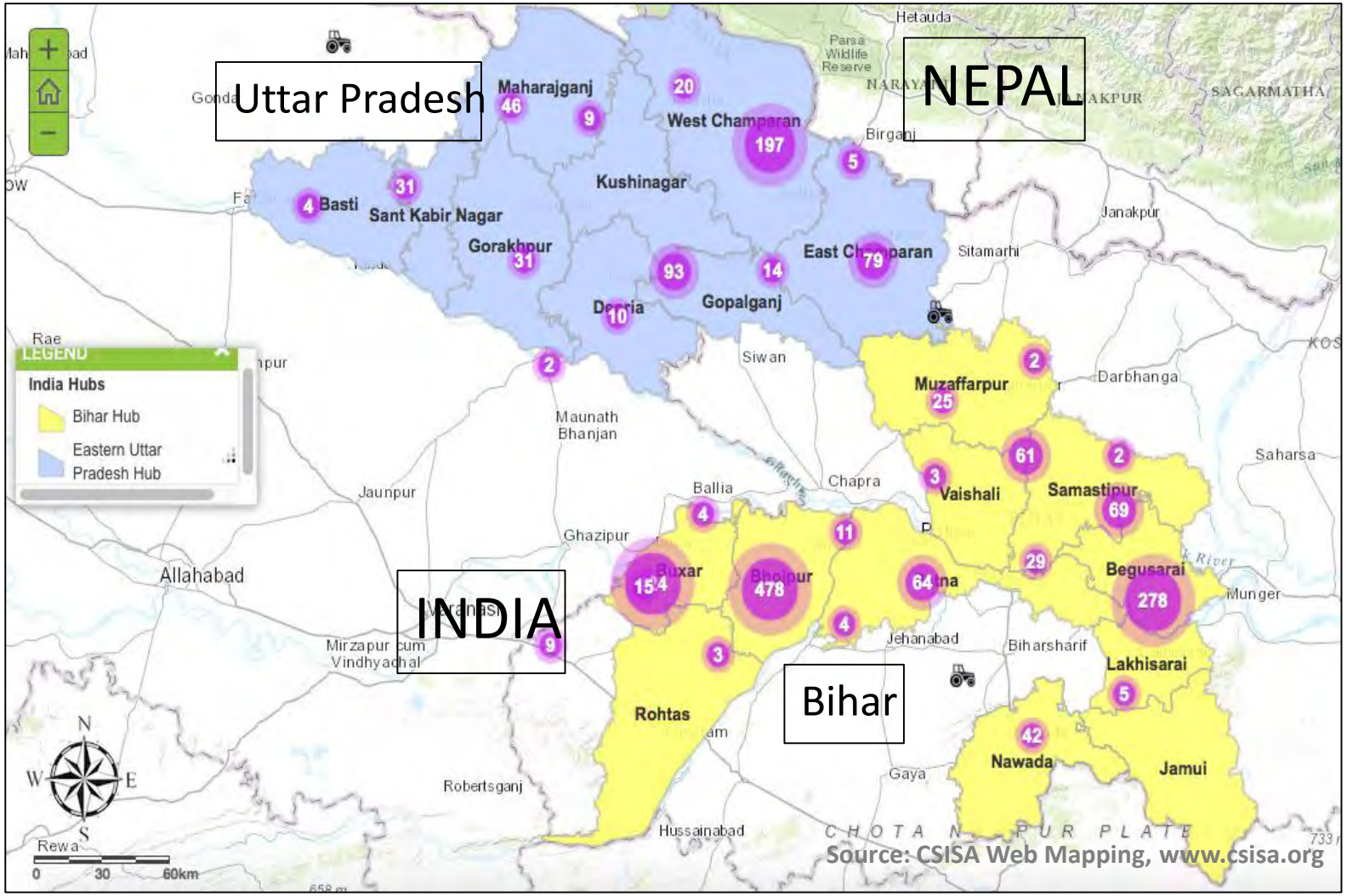
'a network of organizations, enterprises, and individuals focused on bringing new products, new processes, and new forms of organization into economic use…..' (World Bank 2006)



Analysis: J. Andersson

CSISA's work plays complementary and catalytic roles by engaging and uniting partners for indirect impact pathways

For example: number of Zero Till Service Providers in Bihar and Eastern UP Hubs



Source: CSISA Web Mapping, www.csisa.org

Lessons learnt : Agricultural innovations for impact and scale

- **Change from mission oriented top- down approach to diffusion oriented or bottom- up approach.**
- **Strategic partnerships (public + private sectors)**
- **Strengthening markets and scale appropriate mechanization.**

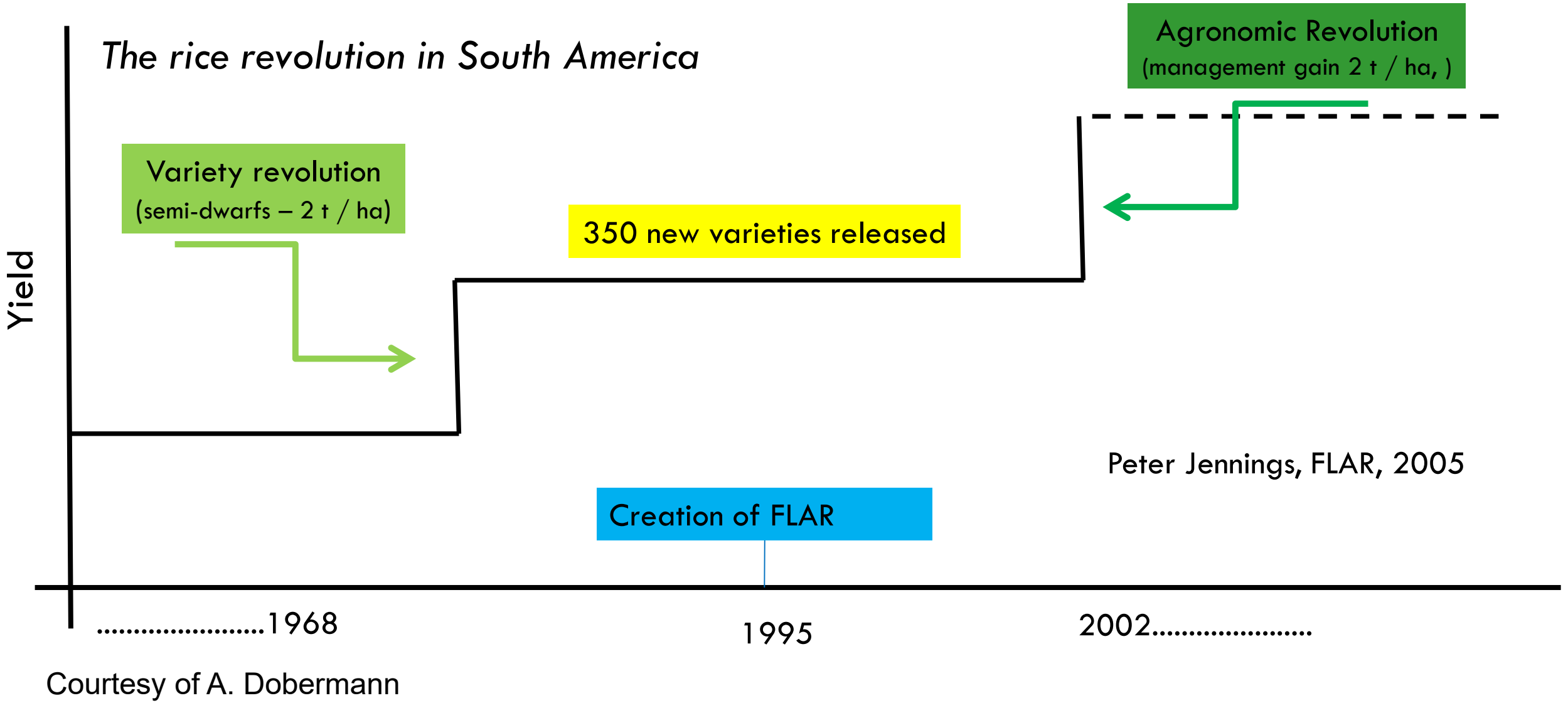
- **Will diversification 'work' for arresting groundwater depletion in the NW IGP? Policies to increase the price of water? Diversification within RWCS will work?**
- **Yield plateaus and climate change. What happens if global temperature continues to rise? What can help? Effective evolution of agronomic management , delivery process and policies**
- **Breeding for high-yielding and stress-tolerant rice and wheat cereal varieties**
- **Strengthen the data collection and statistical packages on why some technologies fly and some flop.**
- **Technology flow across South Asian countries should be encouraged**

Record wheat 7.3 t/ha eastern UP, 2011-12 , with best bet technology

The development and delivery of technologies is greater than the sum of its parts

- **Why green revolution scaled-out in late 1960s and 1970s ?**
- **Because imported seed directly went to farmers field, tested, assessed, validated and accepted**
- **Why BT cotton adoption was more rapid and pervasive?**
- **Because it brought big advantage out of crisis and farmers created pressure for policy**
- **Why zero tillage is more transformational?**
- **Because it was a paradigm shift and mind-set issue**
- **Why hybrid rice adoption is more in Bihar and Jharkhand?**
- **Because we were not able to replace any competitive variety against MT 7029 . Also hybrids could fit the stress environment**
- **Why laser land levelling was adopted with no research in India?**
- **Because it had a business case and tested and adopted at the same time.**
- **Why early wheat sowing was accepted in all ecologies ?**
- **Because every thing was tried and tested at farmers fields**

Acceleration of Management Gains



Courtesy of A. Dobermann