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Diffusion of Machine Harvestable Chickpea and its Impacts on Mechanization and Labor Market in India

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Introduction

- 3rd most important pulse crop in the world & **cheap source of protein**
- Cultivated in around 11 MHa (16% of global total pulses area)
- South Asia occupies about 80% (**2/3rd of the global area in India**)
- Chickpea is a **cool season** crop grown in the Rabi (post-rainy) season
- Short crop architect – harvested and threshed manually (women)
- Rising labour wage rates & increasing competition for hire labour during harvest -↑CoP & ↓ farm profits
- In response to farmers' demand for **Machine-harvestable chickpeas** – ICRISAT developed MHCP cultivars (Erect, tall, first pod above 25cm from ground)

Machine-Harvestable Chickpea Cultivars

1. ICRISAT with NARES partners (ICAR and SAUs) developed and released MHCP cultivars from 2016
2. So far released 5 varieties

S. NO	Cultivars	Year of Release	Partner/States
1	NBeG 47 (ICCV 05106)	2016	ANGRAU, AP
2	RVG 204 (ICCV 08102)	2017	RVSKVV, MP
3	Phule Vikram (ICCV 08108)	2017	MPKV, MP
4	BG 3062 (ICCV 08112)	2019	IARI, Central India
5	NBeG 776	2022	ANGRAU, AP

3. High-yielding, wilt-resistant, and suitable for machine harvesting

Objectives

1. Address **constraints to MHCP adoption** and evaluate the cost-effectiveness of MHCP in a real-world setting
2. Test whether the **one-time intervention (the RCT) led to sustained changes in planting and harvesting patterns** by following farmers for multiple seasons
3. Study the impact of this technology on **local labor markets**.
    a) Understand the impact of MHCP varieties on local labor markets, for women in particular
    b) Understand the impact on the economic agency of female agricultural laborers as well as factors influencing female labor supply

Treatment, Design, and Randomization

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- **Treatment**
  - Provision of free MHCP seed sufficient for one acre of land
- **Design (3 arms)**

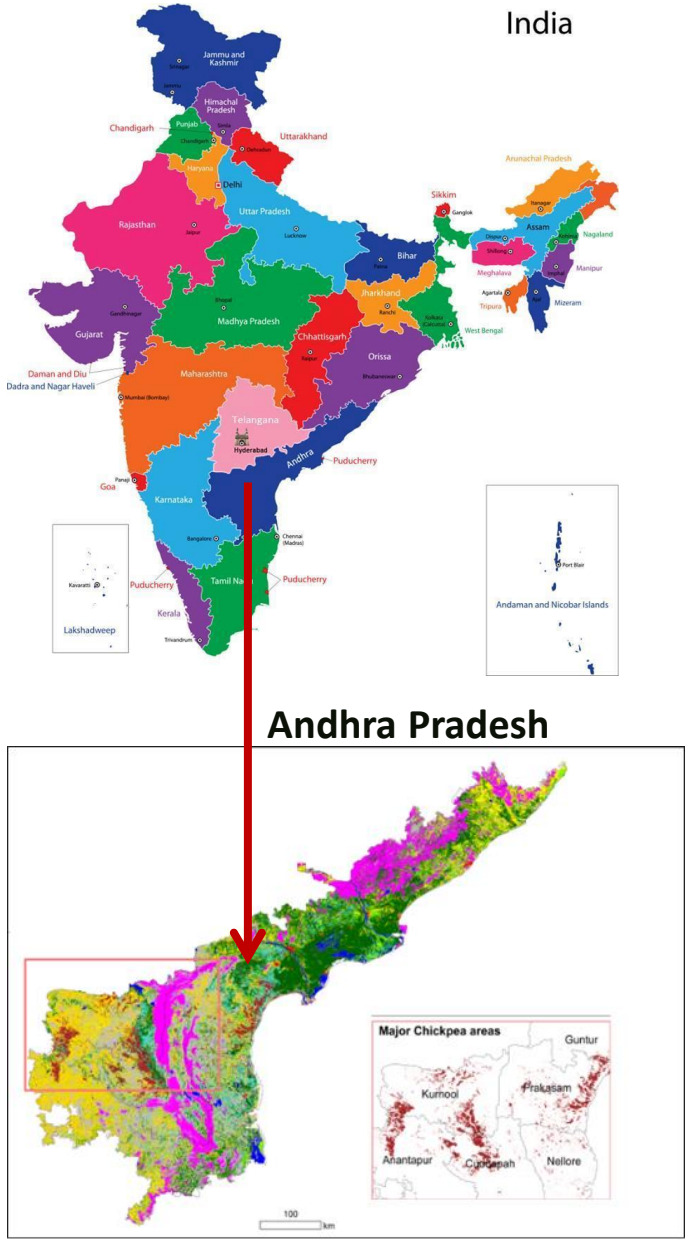
  1. A **pure control group** where no intervention took place
  2. Treatment arm 1 (T1):

     A **⅓ group where-in 33%** of eligible farmers were offered the opportunity to sign-up for planting MHCP
  3. Treatment arm 2 (T2)

     A **⅘ group where 80%** of eligible farmers were offered the opportunity to sign-up for planting MHCP
- **Stratified Randomization**
  - 1st Stage: Villages randomized into one of the three arms.
  - 2nd Stage: Random choice of a set of eligible farmers in study villages to receive an offer to sign up for the MHCP Diffusion Program.

Sample

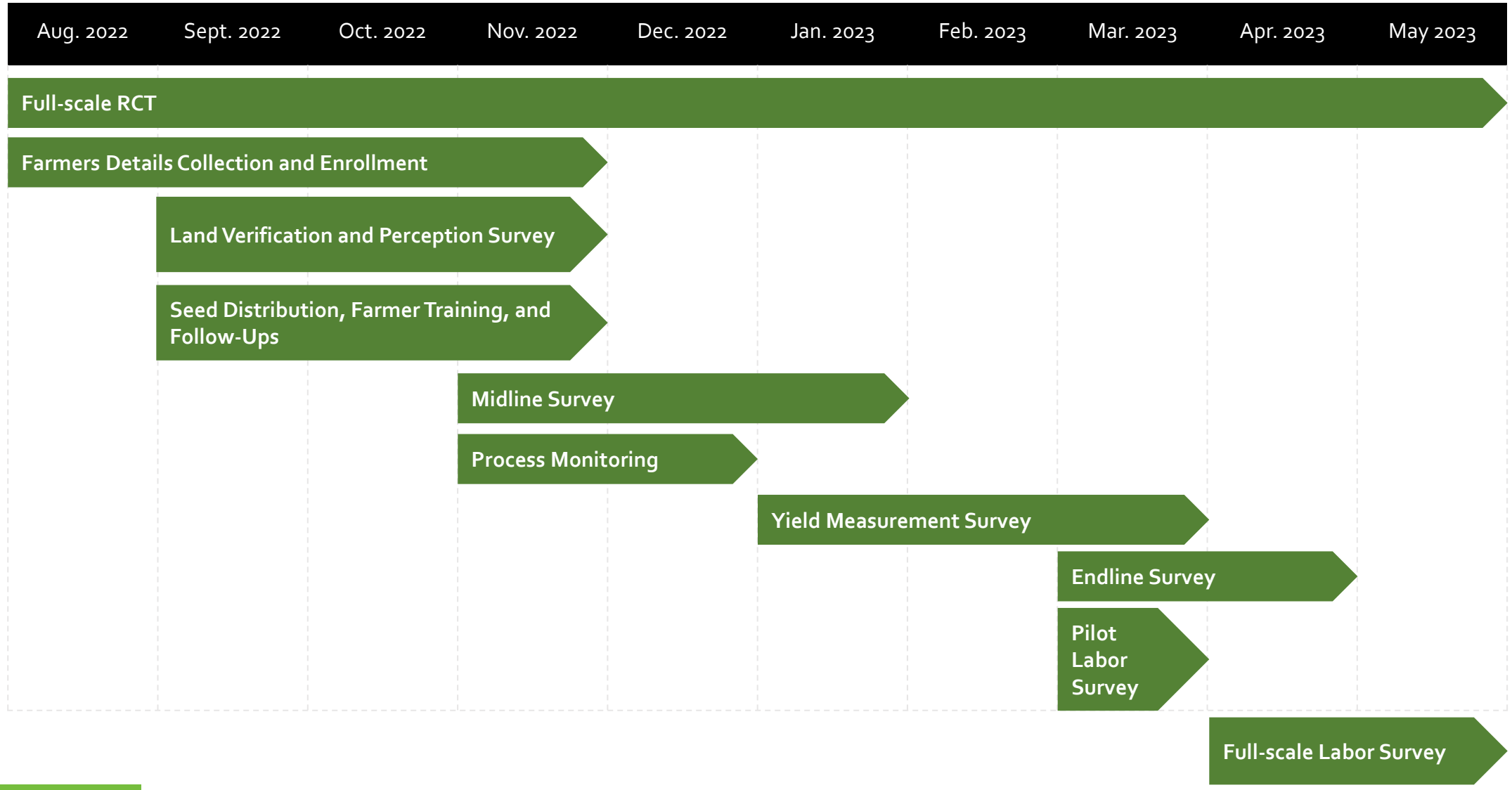
- 85 villages across Kurnool (37), Kadapa (36), and Prakasam (12)
- **Treatment farmers: 486**
  - NBeG-776 for 255 farmers (Released in 2022)
  - NBeG-47 for 231 farmers (released in 2017)
- **Control farmers: 842**



Timeline (Pilot study)

Small-Scale Pilot Survey in Kurnool District of Andhra Pradesh
Objective: To identify problems (and their solutions) in the research design and the implementation plan for the full-RCT

Timeline (Full-scale RCT)



Timeline

○ Midline Survey (November 2022 – January 2023)

- Survey Instrument:
  - Modified baseline survey instrument to prevent respondent fatigue.
  - 2 versions: treatment and control

- Modules:
  - Identification (treatment and control)
  - Household listing and demographics
  - Dwelling characteristics
  - Income (past year)
  - Land details
  - Livestock ownership
  - Assets owned
  - Plot details (chickpea plots)
  - Inputs for farm operations
  - Harvesting and threshing inputs
  - Harvester usage/schedule
  - Current chickpea season (MHC and non-MHC)

Timeline

- Process Monitoring (November - December 2022)
  - Follow-up with control farmers to confirm sowing.
  - Issues with treatment farmers not sowing provided seeds.
  - Follow-up to check damage post-cyclone Mandous.
  - Follow-up to confirm harvest dates and plans.

- Yield Measurement Survey (January - March 2023)
  - Strict protocols to prevent self-reporting.
  - Prioritization based on in-person weighing, the use of machine harvesters, and receipts.

Timeline

○ Endline Survey (March - April 2023)

- Sample Size:
  Treatment: 310 farmers
  Control: 433 farmers

- Survey Modules:
  - Identification
  - Social networks/decisions
  - Crop damage
  - Plot details (chickpea plots)
  - Inputs for farm operations
  - Harvesting and threshing inputs
  - Harvester usage/schedule

- Phone and in-person surveys

○ Full-Scale Labor Survey (April – May 2023)

- Sample Size and Locations:
  Female laborers
  Labor colonies
  Total: 3600 respondents across 84 villages
  Kurnool: 1501 respondents across 35 villages
  Kadapa: 1714 respondents across 40 villages
  Prakasam: 385 respondents across 9 villages

- Survey Modules:
  - Agricultural labor
  - Non-agricultural labor
  - No labor work
  - Unpaid labor work
  - Miscellaneous
  - Gender module
  - Planned labor

Results: Agricultural Effects

Result 1: Harvester Usage

- **30% of treatment farmers** used a combined harvester, 13% higher than control farmers.

Category	n	Combined harvester usage	Harvester usage (%)	P value
Control	419	74	17.66	p<0.01
Treatment	306	91	29.73	

- 26% of treatment farmers cultivated both MHC and non-MHC varieties employed a combined harvester.

- Constraints of Machine Harvesters: **delayed availability and crop damage**.

Category	n	Combined harvester usage	Harvester usage (%)
Control	419	74	17.66
Treatment: MHC	306	86	28.34
Treatment: non-MHC	249	69	27.71
Treatment: Both MHC and non-MHC	249	64	25.70
Treatment: only non-MHC	249	5	2.01

Results: Agricultural Effects

Result 2: Yield Equivalence

Chickpea yields (Quintal/acre)

	Variable	Obs.	Mean	Std. Dev.	Min	Max
Treatment	MHC	306	6.207	2.270	1	15.12
	Non-MHC	246	6.046	2.803	0.10	13.33
Control	Non-MHC	418	6.002	2.436	0.35	15.75

Yield per acre by MHC variety (Quintal/acre)

	Variety	Obs	Mean	Std. Dev.	Min	Max
Treatment – MHC	NBeG-47	152	5.650	2.21	1	12
Yield per acre	NBeG-776	154	6.748	2.19	1.5	15.12

A significant difference between MHC seed varieties - **NbeG-776 showing higher yields (around 100kg/acre)**.

Results: Agricultural Effects

Result 3: Lower Costs of harvesting

- **Lower associated costs** for farmers using combined harvesters compared to manual labor **(Rs. 1000/acre)**

Harvesting cost (INR/Acre)

	Treatment				Control				
	MHC -used harvesters	**MHC - didn't use harvesters**	**Non-MHC - used harvesters**	**Non-MHC - didn't use harvester**	**Used harvester**	**Didn't use harvester**	**1/5th Control**	**2/3rd Control**	**Pure Control**
n	86	210	69	110	74	297	138	46	186
Mean	**2275.79**	**3536.25**	**2250.056**	**3158.38**	**2349.01**	**3197.69**	**2962.51**	**3177.96**	**3041.76**
SD	481.57	1550.57	514.86	1506.61	356.62	1485.62	1283.30	1264.72	1481.21
Minimum	500	366.67	833.33	250	1000	83.33	500	1325	83.33
Maximum	3500	9618.18	3875	9577.77	3636.36	9766.67	9766.67	7700	9000

Results: Agricultural Effects

Result 4: Willingness to Pay for Harvester and Seeds

- Farmers **willing to pay Rs.1940 – Rs.2185 per acre** for the harvester.
- A higher percentage of treatment farmers are willing to pay for MHC seeds.

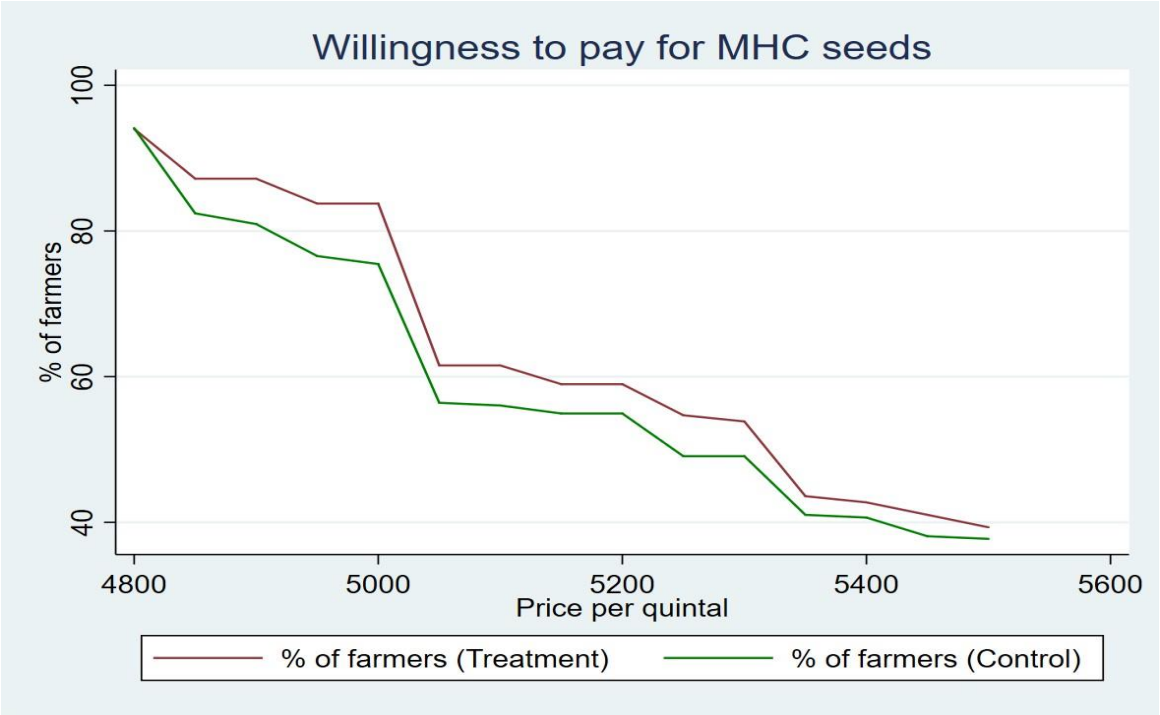
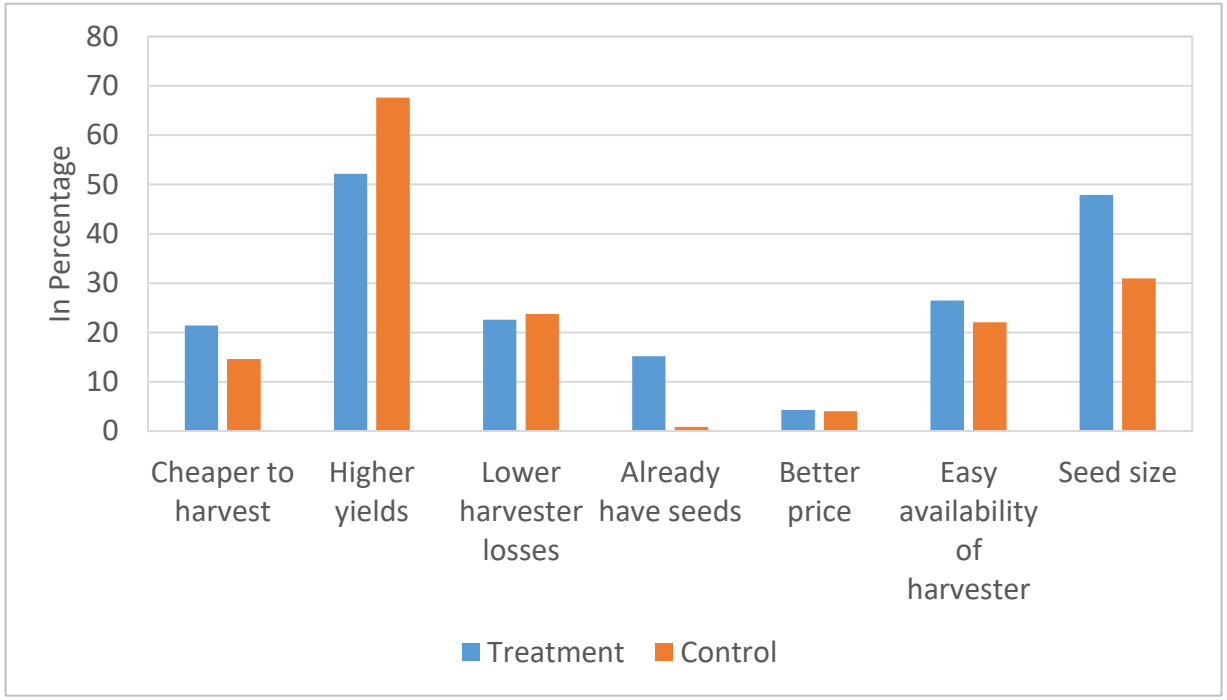


Fig: WTP for MHC seeds (INR/Quintal)

Results: Agricultural Effects

Result 5: Interest in Growing MHC in the Next Season

- **84% of treatment farmers and 83% of control farmers** are interested in growing MHC.
- Reasons include **higher yields and seed size**.
- Preference for **MHC over traditional variety**, especially among treatment farmers.



Results- Labor Effects

Result 1: Impact on Labor Markets

Female Labor Force Participation

- The proportion of the labourers who worked on agriculture increased from 87% in 2022 to 94% in 2023.

Table: Were you engaged in any agricultural labor work?

	Jan- March (2023)		Jan-March (2022)	
	Freq.	Percent	Freq.	Percent
No	227	6.31	455	12.64
Yes	3373	93.69	3145	87.36
Total	3600	100	3600	100

- Increase in the number of labourers engaging in major agri activities in chickpea like harvesting, threshing and weeding.

Year	Jan-March 2023		Jan-March 2022	
Agri Activities	Freq . (n=2571)	Percent	Freq . (n=2274)	Percent
Harvesting	2026	78.8	1761	77.44
Threshing	1272	49.97	1017	44.72
Weeding	1065	41.42	869	38.21
Pesticide application	56	2.18	98	4.31
Transportation	1	0.04	2	0.09
Other specify	0	0	2	0.09

Results: Labor Effects

Result 2: Impact on Labor Markets

Female Labor Force Participation

- Slight decline in the number of labourers engaged in chickpea between 2022 and 2023 in the T1 treatment arm.

Table: Labor engaged in chickpea cultivation

	Jan-March 2023		Jan-March 2022	
	Freq .	**Percent**	**Freq .**	**Percent**
Pure control	780	30.34	688	30.26
T 1 (1/3rd treatment)	940	36.56	844	37.12
T 2(4/5rd treatment)	851	33.1	742	32.63
Total	**2571**	**100**	**2274**	**100**

- The number of agri labourers who are engaged on chickpea increased by 4% even though the same fell for other prominent crops.

	2023		2022	
Crop name	Freq. (n=3373)	Percent	Freq. (n=3145)	Percent
Chickpea	**2571**	**76.22**	**2274**	**72.31**
Cotton	2007	59.5	1953	62.1
Maize	220	6.52	217	6.9
Red gram	171	5.07	215	6.84
Onion	151	4.48	155	4.93
Chilly	538	15.95	524	16.66
Banana	111	3.29	116	3.69
Groundnut	456	13.52	452	14.37
Sesame	63	1.87	49	1.56
Vegetables	141	4.18	138	4.39
Mango	1	0.03	1	0.03
Mosambi	328	9.72	301	9.57
Tobacco	178	5.35	163	5.26
Others	218	6.46	138	4.39
Paddy	209	6.2	164	5.21
None	3	0.08	2	0.06

Results- Labor Effects

Result 3: Impact on Labor Markets

Number of Days Worked

- Slight decline in the number of days engaged by the laborers in harvesting chickpeas in T1.
- The number of days of work in threshing **declined** in both the T1 and T2 treatment arms while it **increased in the pure control villages**.

	Increase in harvester usage in 2023 compared to 2022 (%)	**Additional workers engaged in harvesting in 2023 compared to 2022 (%)**	**Additional workers engaged in threshing in 2023 compared to 2022 (%)**
Pure Control	3.67%	0.42%	1.45%
T1 (1/3rd treatment)	17.78%	-0.18%	-0.13%
T2 (4/5th treatment)	8.44%	1.91%	-3.62%

Results- Labor Effects

Result 3: Impact on Labor Markets

Additional labor engaged in harvesting in the same village

- Slight decline in the female labor engaged in harvesting chickpeas within their own village in treatment villages.
- suggest female labor displaced due to MHC seek work in the location further away from their own village.

	Increase in harvester usage in 2023 compared to 2022 (%)	Additional labor engaged in harvesting in 2023 compared to 2022 (%)
Pure Control	3.67%	0.31%
T1 (1/3rd treatment)	17.78%	-1.19%
T2 (4/5th treatment)	8.44%	-1.00%

Summary

- Harvester usage is **10% higher** for treatment farmers
- Yield difference of **85 kg/ha for the MHC variety** over the non-MHC variety
- Substantially higher yield difference between treatment and controls, particularly for treatment farmers randomly assigned to NBeG-776.
- Operating costs were lower for treatment farmers who used harvesters by **40.5%**
- **Farmers interested in growing the MHC** variety irrespective of their treatment status
- The WTP for the MHC seeds is similar between the treatment and control farmers at the lower bound of price; as the price increases, **the percentage of treatment farmers' WTP is higher**
- Proportion of female workers engaged in chickpea harvesting, and threshing falls in the treatment villages

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