Crop based Demonstrations and Trials under Farming System for Nutrition Study in Wardha (2013-16)

A Report

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Dr. Aliza Pradhan, Dr. A V Vijaya Bhaskar* and Mr. Mahesh Maske*

M S Swaminathan Research Foundation
3rd Cross Street, Taramani Institutional Area, Chennai
www.mssrf.org

*Have since left the Foundation

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About the Report

This Report is a documentation of the crop interventions undertaken as part of the Farming System for Nutrition (FSN) Study under LANSA in Wardha during the period 2013-16.

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1. Introduction

Wardha district is located in the Vidarbha region of Maharashtra state having a geographical area of 6,309 sq km and population of 1.3 million of which 67.5 per cent live in rural areas. The percentage of population living in rural areas in Wardha District is higher than the average of 55 per cent for the state as a whole. The district has a predominantly agrarian economy with 68 per cent of the workers being classified as cultivators and agricultural labourers (GoI 2011). The total cultivable area of the district is 4729 sq km, which is about 75 per cent of the total geographical area of the district (GoM 2006). Further, three-fifths of the cultivated area is with small farmers while two-fifths are with medium and large farmers. Wardha district forms a part of Wardha river basin. The agro-climate of the district is characterised by hot, dry, and sub-humid climate with dry summers and mild winters. Kharif has always been the most important season with regard to area under cultivation. The kharif season begins in mid-June with the onset of the monsoon and extends upto December depending on the type of crop sown. The rabi season commences in October and extends upto February or March.

The main crops grown in kharif season are cotton, sorghum and pulses; and also soybean since the mid-1980s. The cropping pattern of the district could be described as cash crop based production system with cotton and soybean together accounting for about 75 per cent of the gross cropped area as of 2008-09[1]. Intercropping of cotton with pigeon pea (6:2) is a common practice in the region followed by wheat and gram in the rabi season. Agriculture in the district is primarily rainfed and dependent on the southwest monsoon. The district receives an average annual rainfall of 1041 mm. Black soil is the predominant soil type in the district and it is classified into heavy, medium and light categories; the soil has low water holding capacity. The predominant source of irrigation in the district is ground water with 85 per cent of the total operational holding that is irrigated depending on open wells as a source

[1] http://www.zpwardha.in/departments_agriculture.php

2 www.agcensus.nic.in; World agricultural census 2000-01. The total number of operational holding receiving irrigation as of 2000-01 is 21124 hectare.

of irrigation by 2001-02[2]. This accounts for 83 per cent of the total net irrigated area in the district (GoM, 2005). South west monsoon- the lifeline of agriculture in Wardha district is erratic in nature, is skewed in its distribution, and shows a declining trend since 1967 with a reduction in the number of rainy days (MSSRF 2010) and consequent serious implications. Soil and water runoff has very severe adverse impact on soil nutrient status, crop productivity and sustainability.

Wardha falls in the list of districts with high burden of malnutrition. As per NFHS-4, 30.5 per cent of children under five years are stunted, 26.2 per cent are wasted and 36.1 per cent are underweight, 42.5 per cent of women (15-49 years) are anaemic (GoI, 2016).

The district is one of the locations of the Farming System for Nutrition (FSN) study led by the M.S. Swaminathan Research Foundation (MSSRF) under the research programme on Leveraging Agriculture for Nutrition in South Asia (LANSA). The FSN study potentially seeks evidence on "How agricultural interventions can be pro-nutrition?" It involves a combination of sustainable agricultural remedies ranging from advanced crop production practices, bio-fortification, promotion of nutrition gardens of fruits and vegetables, livestock and poultry development, setting up of small-scale fisheries and regularizing veterinary services, designed and tailored to the existing resource base, as stimulant for rendering consistent output of higher income and better nutrition (Das et al 2014; Nagarajan et al 2014). The underlying assumption is that nutritional outcomes in a rural population improves through production and own consumption of nutrition-rich diverse diets or alternatively through higher incomes from sale of agricultural produce which is in turn used for addition or enrichment of diet with multi-nutrition-rich foods to often consumed staples (World Bank 2007; Masset et al., 2011). The main purpose of FSN is to understand the farming systems and improve the same especially the crop components with nutrition point of view.

This report documents the different crop demonstrations and trials undertaken as part of the study in a set of villages in Wardha district, during the period June 2013 to March 2016.

2. FSN study Approach

The FSN study is underway in three villages in Arvi block and two villages in Karanja block of Wardha district. The criteria for selecting the villages were based on the, dominance of tribal communities, proximity to watershed area and previous experience of MSSRF with the local community.

Detailed baseline survey and focus group discussions were undertaken from June 2013 to September 2014 to identify the existing disconnect between agriculture and nutrition linkages. Concurrently, a number of crop-based FSN demonstrations and trials fitting into local resource base were undertaken in joint discussion with and participation of community members and stakeholders. The agricultural university and research institutes in the region were also consulted.

Following analysis of the baseline survey data and analysis of existing cropping scenarios, the crop-based FSN approach was further intensified in consultation with the community and stakeholders. For example, improved production practices of underutilised and nutrient-dense crops like sorghum and pulses besides improving wheat production, emerged as the focus areas.

3. Baseline survey findings

Information regarding demographic profile, predominant crops and cropping patterns, anthropometric and biochemical status of the population, food consumption pattern, dietary diversity and sources of food was collected through baseline surveys. With regard to demographic profile, there are less females to males in each category of age classification and a majority of the households are having 1-4 members followed by households of 5-7 members (see Tables 1-2). Other key findings from the baseline survey are discussed below.

Table 1: Distribution of population by age in the study area

Age Classification in years	Number of Male	Number of Female	*Sex Ratio
0 to 5 years	109 (4.8)	88 (3.9)	807
6 to 11 years	81 (3.6)	71 (3.1)	877
12 to 17 years	135 (6.0)	115 (5.1)	852
18 to 44 years	495 (22.0)	462 (20.5)	933
≥ 45 years	357 (15.8)	341 (15.1)	955
Total	1177 (52.2)	1077 (47.8)	915

(% figures in parentheses) Source: Baseline Survey 2014

*Sex ratio is calculated by dividing no. of females to no. of males multiplied by 1000 and the value indicates the no. of females to 1000 of males.

Table 2: Distribution of households by family size

Family Size	Households
1 to 4 Members	348 (62.6)
5 to 7 Members	195 (35.1)
>= 8 Members	13 (2.3)
Total	556 (100)

(% figures in parentheses) Source: Baseline Survey 2014

3.1. Occupation of the head of the household and sources of family income

The population of the sample villages in Wardha district is predominantly dependent on agriculture. The occupational structure indicates cultivation and agricultural labour as the primary occupation of majority of head of the households (96 per cent) in the study villages (Table 3).

Table 3: Distribution of Households by Primary and Secondary Occupation of Head of the Household

Occupation	Primary	Secondary
Cultivation	351 (63)	32 (6)
Agricultural wage labour	182 (33)	257 (46)
Non agricultural wage labour	6 (1)	5 (1)
Artisan/independent work	5 (1)	10 (2)
Others	12 (2)	33 (6)
No Secondary occupation	-	219 (39)

Total no. of households (N) =556 Source: Baseline Survey 2014
(% figures in parentheses)

3.2. Land and livestock Resources

175 of the 556 households or 31.5 per cent were found to be landless. 38.6 per cent are small and marginal farmers with less than two hectares of land (Table 4). Five households are large farmer households with more than 10 hectares of land, the average land size being 13.77 hectares; 121 households have 2 to 4 hectares of land and the remaining 40 households have land between 4 to10 hectares. Only 97 of the 556 households reported having home gardens. About 43% of the households reported possession of livestock in study villages. Most of the cattle in the villages are milch animals such as cows and buffaloes. Some households also possess draught animals for ploughing and transport such as bullocks. A few households keep

poultry as well as small ruminants such as sheep, goats, pigs. The possession of livestock according to the land classes shows that the largest number of milch cattle and draught animals are with medium sized land holding size of 2.5 to 10.00 acres. This group also owns most of the small ruminates and poultry, though the landless are the next important owners of small ruminates and poultry.

Table 4: Distribution of households according to the size of the Land holding

Land class	**Frequency**
Land less	175 (31.5)
Marginal (< 1 ha)	64 (11.5)
Small (1 - < 2 ha)	151 (27.1)
Semi-medium (2 - < 4 ha)	121 (21.8)
Medium (4- 10 ha)	40 (7.2)
Large (>10 ha)	5 (0.9)
Total	**556**

(% figures in parentheses). Source: Baseline Survey 2014

3.3. Cropping system

Among Kharif growers, 24% of farm-households practice intercropping of cotton with pigeon pea. Typically, cotton + pigeon pea occupies bulk portion of land area and these cultivators also use some proportion of cotton + pigeon pea land area to cultivate either soybean (21% of households) or sorghum (15% of households) and sometimes both (15%) (Table 5). The variety used in cotton is Bt cotton hybrid seeds. Very few households practice sole cropping i.e. soybean (5%) or sorghum (1%). Only 15 per cent of the *kharif* season cultivator households (n= 58) go for rabi season crops i.e. wheat, bengal gram.

Table 5. Prevalent cropping system or crops grown in the study region

Major Cropping Season	Major cropping systems	Percentage of HHs practicing the cropping pattern
*Kharif (June-October)	Cotton + Pigeon pea	24
	Cotton + Pigeon pea + Soybean	21
	Cotton +Pigeon pea + Soybean +sorghum	17
	Cotton +Pigeon pea +sorghum	15
	Soybean	5
	Cotton +Soybean +sorghum	5
	Cotton + Soybean	4
	Sole sorghum	1
	Others (Cotton + sorghum/ cotton + green gram/ Soybean + sorghum/ Pigeon pea + Soybean)	9
Rabi (November-February)	Wheat	57
	Bengal gram	31
	Wheat + bengal gram/maize/sorghum	12

*extends up to December depending on the type of crop sown.

3.4.Anthropometric and biochemical measurement findings

The prevalence rates of chronic energy deficiency, underweight, stunting and wasting were calculated based on the cut off limits given by World Health Organization standards (http://www.who.int/nutgrowthdb/about/introduction/en/index5.html). In the study locations, forty three per cent of children under age five reported underweight (low weight for age), forty per cent stunted (low height for age) and about twenty seven percent wasted (low weight for height). Further, about 30 % of school-age children (5-9 years) and about 52% and 57% of adolescents (10-14 and 15-17 years) were undernourished. Also the percentage of women (49%) with CED (BMI<18.5) was found higher than the men (39%) (Fig. 1).

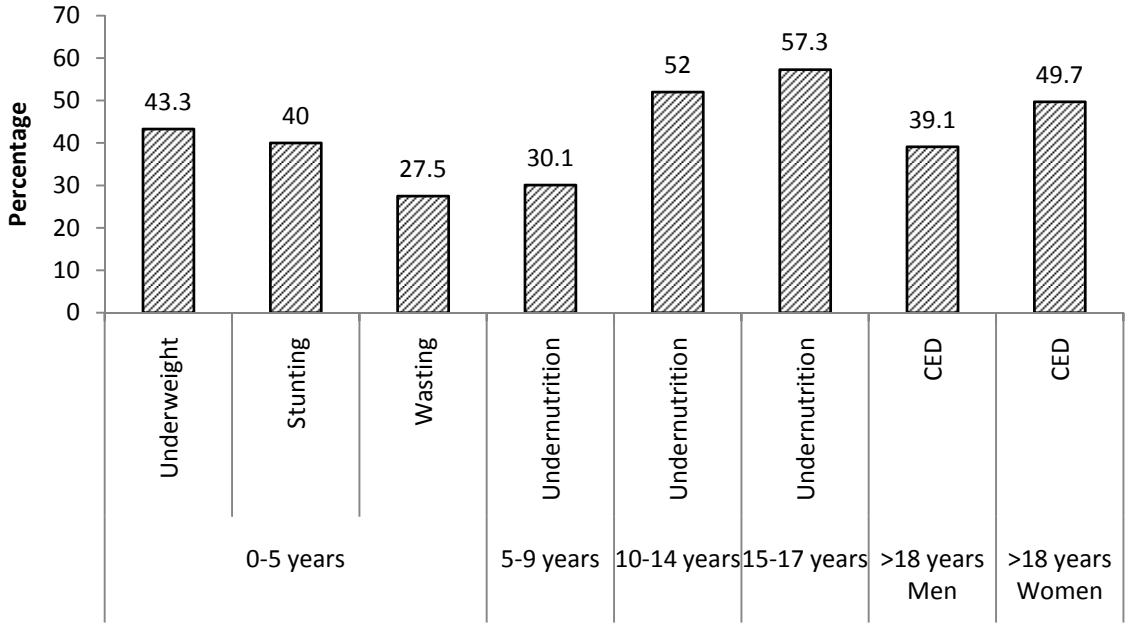

Fig. 1. Status of Undernutrition in the study area (Source: Baseline Survey 2014)

(Total no. (N) under different age groups are: (1-5 yrs: 120); (5-9 yrs: 103); (10-14 yrs:175);(15-17 yrs: 82); (>18 yrs Men:739) & (>18 yrs Women: 702).

The biochemical analysis indicated that about 83% of children under age five and around 80 % of girls in the age groups of 12-14 and 15-17 years were reported to be anaemic. The percentage of non-pregnant non-lactating women having anaemia was 86%. Further, about 62 per cent of pregnant women and 75 per cent of lactating women were reported to be suffering from anaemia. It was also found that about 35% of children under age five were having vitamin A deficiency (VAD).

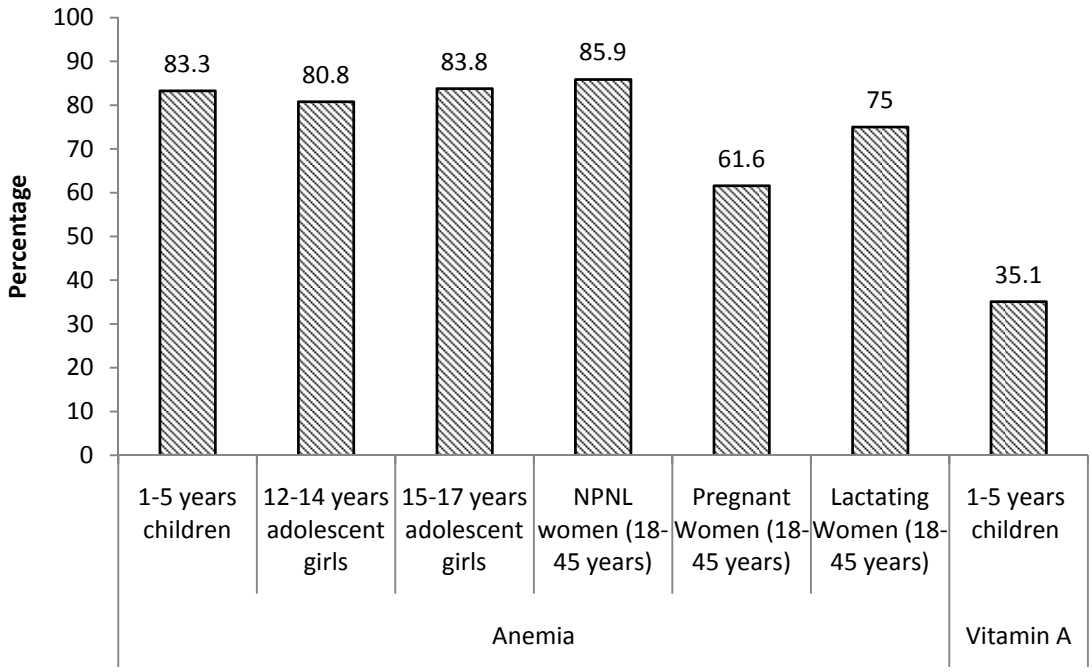

Fig. 2. Status of micronutrient deficiency (Anaemia and Vit A. deficiency) in the study area (Source: Baseline Survey 2014)
(Total no. (N) under different age groups are: (1-5 yrs: 90); (12-14 yrs adolescent girls: 52); (15-17 yrs adolescent girls: 37);(NPNL: 355); (Pregnant women:13) & (Lactating Women: 20).

3.5. Food consumption pattern and dietary diversity

The proportion of households consuming cereals and millets in quantities <70 percent of the Recommended Daily Intake (RDI) was found to be 30.4% (Table 6). The consumption of wheat (216 g/day) was high followed by rice (102.6 g/day). The average consumption of pulses was 57.5 g/day compared to the RDI of 75g/day; the percentage of households consuming pulse <70 % of RDI was 56.5%. The average daily consumption of green leafy vegetables and fruits was well below the suggested level of 100g. More than ninety five percent households consume green leafy vegetables <70 % of RDI. The average daily consumption of root and tubers and other vegetables was well below the recommended level of 200g. Almost all the households consume root and tubers and other vegetables <70 % of RDI. The average consumption of fish or other sea foods was around 16 g/day. Similar intake pattern was observed for meat and poultry products. The average intake of milk and milk products was well below the RDI levels, with more than ninety-nine percent of households consuming <70 % of RDI. However, majority of the households (above 60 per cent) were having edible oils and sugar products >70 per cent of RDI.

Table 6. Average intake of food groups (g/CU/day) and their frequencies (%) as per levels of their consumption (% RDI)

FOOD GROUPS	FSN villages (N: 150)		RDI*	Frequency distribution (%) as per levels of consumption (% RDI)		
	Mean	±SD		<50	50-70	>70
Cereals & Millets	323.1	92.1	375	3.1	27.3	69.6
Cereals	318.3	83.6				
Millets	1.4	8.0				
Pulses & Legumes	57.5	47.0	75	39.1	17.4	43.5
Green Leafy Vegetables	11.2	23.2	100	90.0	5.0	5.0
Roots & Tubers	28.5	22.0	200	98.8	1.2	0.0
Other Vegetables	32.0	35.4	200	94.4	5.6	0.0
Fruits	1.6	4.1	100	93.2	3.1	3.7
Fish & other Sea Foods	15.8	8.7	-			
Meat &Poultry	16.8	27.0	-			
Milk & Milk Products	0.0	0.0	300	97.5	2.5	0.0
Fats & Edible Oils	5.2	20.0	25	14.3	25.5	60.2
Sugar & Jaggery	28.2	39.3	20	3.7	6.2	90.1

Source: Baseline Survey 2014

* Recommended Dietary Intakes as per Dietary Guidelines for Indians, ICMR, 2011

(As there is no RDI for meat and fish, the frequency of consumption was not calculated)

3.6. Sources of food

With respect to food source, about 76% of households reported sourcing wheat and rice from the market, 22.3% from the public distribution system (PDS) and 1.7% consume cereals and millets produced from their land (Table 7). Majority of the households reported market as a major source for pulses, fruits and vegetables for majority of the households in the area.

Table 7. Percent Households according to major source of the commodity commonly consumed under different food groups

FOOD GROUPS	Percent households according to major source of commodity, averaged over three seasons (n=556)			
	Home Grown	Purchased from PDS	Purchased from Open Market	Other Sources
Cereals & Millets	1.73	22.30	75.93	0.07
Cereals (Rice and wheat)	2.57	23.30	74.10	0.10
Millets (sorghum)	40.50	0.00	56.50	3.00
Pulses & Legumes	20.00	0.00	79.17	0.83
Green Leafy Vegetables	2.80	0.00	92.07	5.17
Roots & Tubers	0.50	0.00	99.10	0.40
Other Vegetables	1.80	0.00	98.00	0.20
Nuts & Oil Seeds	0.27	0.00	99.63	0.10
Condiments & spices	0.47	0.00	99.50	0.03
Milk & Milk Products	12.70	0.00	4.50	82.80
Fruits	1.37	0.00	98.10	0.50
Fish & Other Sea Foods	0.00	0.00	100.00	0.00
Meat & Flesh Foods	0.67	0.00	99.20	0.13
Fats & Oils	4.13	0.00	82.03	13.83
Sugar & Jaggery	0.00	0.30	99.57	0.13

4. Existing disconnect between Agriculture and Nutrition

Based on the baseline surveys conducted, following few agriculture nutrition disconnect linkages were found out (Table 8) and accordingly appropriate technologies/approaches in order to address these issues were laid out in discussion with technical experts and villagers.

Table 8. Existing Agriculture Nutrition disconnect linkages in study villages of Wardha

Agriculture	Nutrition	Proposed Strategy
• Less productivity of sorghum and reduction in the area under cultivation	• Gap between demand and supply (57% purchased from market)	• Improve productivity and area under sorghum
• No major kharif pulse crop area (always intercropped with cotton or soybean) • Less productivity of rabi pulse (Bengal gram)	• 57 per cent of HHs consume pulse <70 per cent RDI	• Sole cropping of pulse (pigeon pea and green gram) • Improve the productivity and area under Bengal gram
• No area under tuber cultivation	• Very less consumption (99 per cent consume <50 per cent RDI) • Vitamin A deficiency in (1-5) yr children (23 %)	• Nutrition awareness • Option for introducing bio-fortified tuber crops (Orange flesh sweet potato; rich in Pro-vitamin A) in home gardens
• Cultivation of vegetables limiting to some groups	• Consumption below RDI • Prevalence of anaemia	• Nutrition awareness • Introduction of nutrition garden (cultivation of different groups of vegetables)
• Livestock used for either cultivation or source of money	• Consumption of animal protein below RDI	• Scope for introducing poultry as an alternative for animal protein source (for landless and marginal farmers)

5. Crop-based FSN interventions

Based on the above agriculture and nutrition disconnect linkages, different crop-based FSN interventions based on following technologies were taken into consideration (See Annexure I).

- Increase cropping intensity;
- Introduce new crops for crop diversity;
- Improved agriculture practices; and
- Increase land use efficiency

Following strategies were adopted to implement the FSN interventions.

On-farm Demonstrations (OFD): The technologies and practices identified for the FSN interventions were developed and tested by PDKV, Akola as part of the state agriculture

development programme. Hence it was decided to demonstrate and fine-tune the different interventions to the local context. In this back drop, OFD was chosen as a potential strategy to implement the FSN interventions. As the baseline survey was underway, 2013-14 and 2014-15 OFDs were mainly to build rapport with the farmer households whereas OFDs during 2015-16 were designed based on:

- ✓ *Baseline survey result*
- ✓ *Existing farming system of the study area*
- ✓ *Nutrition status of the population*
- ✓ *Input from researchers*
- ✓ *Discussion with the villagers to finalize the intervention*

In OFD, each farmer was considered as a replicate. For example, OFD allotted land area was split into known portions to fit farmers's method against recommended agronomic practice. Increasing the treatment or replications within a given land is less feasible. Moreover, the importance of OFD is to mostly follow a comparative approach where farmers can witness the superiority of the crop field and yield performance under proposed production practices under their direct involvement and in their own farm environment. Nevertheless, the involvement of researchers helped to collect some agronomic data (e.g. plant population, plant height, 1000 grain weights) for comparative assessment. Quadrat method was mostly followed with variable replications based on attempted assessment. As the OFDs were mainly considered as entry point activities initially, improved cropping method and/ or varietal trials were feasible only with few participating farmers which further limited the scope of proper statistical analysis. However, average plot yield recorded from the OFDs provided farmers the most crucial criteria to judge and take up the suggested interventions with a nutrition-sensitive focus in future. Additionally, it also suggested that the increased yield if any, will serve as increased availability of nutrient rich food per household. The nutrition composition of different crops being promoted under FSN is given in Annexure II. The economics of production under OFDs included total cost of cultivation, gross return, and net return. The cost of cultivation (A1) included expenses incurred during land preparation/ sowing/ nutrient application/ weeding/ harvest. However, seed cost was not taken into account as seeds of improved varieties were provided by the project and farmers' used their own retained seeds.
Further gross return was calculated by multiplying the total return with their market price while net return was calculated by subtracting total cost of cultivation from gross return.

In this study, OFD followed both single component (e.g. demonstrating high yields from improved varieties) and change in cropping patterns (e.g. encouraging sole cropping of pulses and millet in addition to intercropping of the crops with cotton).

5.1. Rainfall and climate

Wardha District has an extremity in climatic situation. It has very cold winter and Extreme hot summer with unevenly distributed rainfall. The study site receives its rainfall essentially from the south–west monsoon, which accounts for about 85 percent of the total annual rainfall. The north-east monsoon accounts for 9 percent while hot weather and cool weather periods account for 4 percent and 2 percent, respectively. Figure 3 shows the temperature and precipitation during the study period (2013-15).

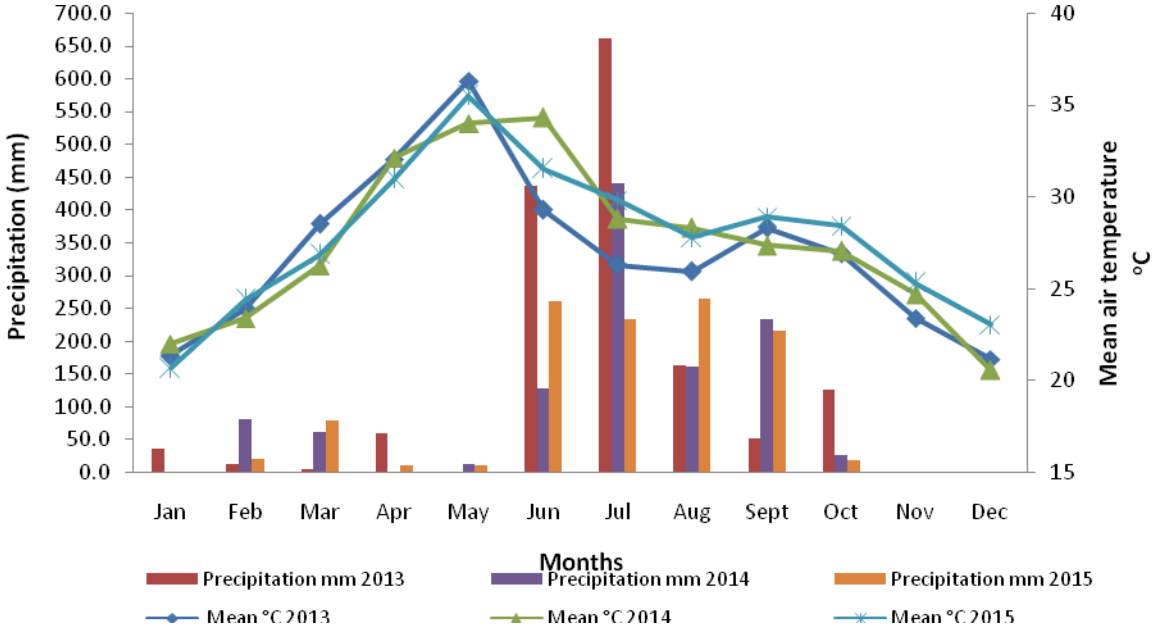

Figure 3: Mean air temperature and amount of precipitation during 2013, 2014 and 2015 crop season. Regional Meteorological Centre, Nagpur

5.2. Soil characteristics

Black soil is the predominant soil type. This is classified into kanhar (Heavy soils), madhyam (Medium soils), and bardi (Light soils). In the district as a whole, the extent of kanhar is 35.4 per cent; madhyam, 43 per cent; and bardi, 20.6 per cent.

5.3.Year-wise on farm demonstrations (OFD) under FSN

5.3.1. 2013 OFD

As the baseline surveys were underway, the objective of OFDs during 2013 was mainly to build rapport with the farmer households and start orienting them on the need for a nutrition focus in agriculture. The OFDs were undertaken keeping in view the existing cropping pattern and farming practices, to examine results with different varieties of the same crop and better cultivation practices.

5.3.1.1. Kharif-2013 OFD

The OFDs in Kharif 2013 were:

i) Evaluation the performance of *desi* cotton variety, Suraj
ii) Assessing the performance of improved variety of pigeon pea as inter crop
iii) Assessing the performance of improved variety of soybean

Each of these is discussed in brief below. The same is done for the rabi season and subsequent years.

Study 1: Evaluating the performance of desi cotton variety-Suraj

Objective: to evaluate the yield performance of desi cotton variety- Suraj.

Materials and methods:

The Central Institute of Cotton Research (CICR), Nagpur recommended desi variety (Suraj) which is early maturing and recommended under high density planting to compensate for fewer pickings. In order to evaluate the yield performance of the suggested variety, an on farm demonstration was carried out during June -December 2013 in twenty selected farmers' fields covering a total land area of 20 acres. A well decomposed farm yard manure (FYM) @ 5 t ha^{-1} was applied and ploughed in using bullock-drawn plough followed by harrowing in order to break up clods and to get a fine tilth. The seeds were sown @ 4 kg ac^{-1} by dibbling method with a spacing of 45x10cm to maintain optimum plant population and also to accommodate pigeon pea as an intercrop. As the general practice of the area is to sow cotton and pigeon pea in the ratio of 6:2, the same was also followed in this study. Further, a blanket recommendation of NPK @ 80:40:40 kg ha^{-1} was adopted. Full dose of P and K was applied at the time of sowing. Fifty percent of N was applied 15-20 days after sowing (DAS) and the remaining fifty percent was applied 40-60 DAS. Other intercultural activities such as weeding and pesticide interventions followed CICR recommendations.

Results:

On an average, cotton lint yield under this high density planting was 400 kg ac^{-1}. However, compared to Bt cotton hybrids from neighboring farmers' field, the yield from this desi Suraj variety under rainfed conditions was 37 per cent less.

Study 2: Assessing the performance of improved variety of pigeon pea as inter crop

Objective: to assess the yield performance of improved pigeon pea variety- Durga

Materials and methods:

An on farm demonstration was undertaken during June -December 2013 in fifteen farmers' fields covering a total land area of 15 acres to evaluate the crop performance of improved pigeon pea variety- Durga (from Nirmal seeds) intercropped with cotton in the ratio 2:6. Each farmers field was divided into two equal splits in order to accommodate improved pigeon pea variety 'Durga' intercropped with cotton against farmers' local pigeon pea varieties intercropped with cotton. However, agronomic package of practices was consistent irrespective of the varieties tested. Well decomposed farm yard manure @ 5 t ha^{-1} was applied during last ploughing, followed by harrowing in order to provide a fine tilth. The pigeon pea seeds were sown @ 5 kg ha^{-1} by dibbling method at the spacing of 60x20cm. Seeds were treated with Carbendazim 50WP @ 3g kg^{-1} seed prior to 24 hours of sowing.

Results:

The harvest results reported the mean seed yield of 330 kg ha^{-1} from improved pigeon pea variety 'Durga', 25.7% higher than the farmers' pigeon pea varieties (263 kg ha^{-1}).

Study 3: Assessing the performance of improved variety of soybean

Objective: to evaluate the yield performance of soybean improved variety-'N-15'.

Materials and method:

This study was undertaken in ten farmers' fields covering a total land area of 10 acres from June - November 2013. A well decomposed farm yard manure (FYM) @ 5 t ha^{-1} was applied and incorporated during last ploughing, followed by harrowing to provide a smooth soil surface. The seeds were sown @ 75 kg ha^{-1} by dibbling method with a spacing of 30x5cm. Seeds were treated with Thiram @ 3g kg^{-1} of seeds and *Trichoderma viride* @ 4g kg^{-1} of seeds prior to sowing.

Results:

The average seed yield was reported to be 1374 kg ha^{-1} (Yield affected due to unseasonal heavy rainfall).

5.3.1.2.Rabi-2013 OFD

The on-farm demonstrations in rabi 2013 covered:

i. Assessing performance of nutrient dense wheat varieties
ii. Evaluating the performance of improved varieties of chickpea
iii. Assessing the performance of improved linseed variety
iv. Assessing the performance of improved mustard variety

Study 1. Performance of nutrient-dense wheat varieties

Objective: to evaluate the yield performance of zinc and iron rich wheat varieties namely AKAW-4627 and NIAW-1415 under irrigated conditions.

Materials and methods:

An on farm demonstration was undertaken in six selected farmers' fields covering a total land area of 3 acres in order to evaluate the field and yield performance of zinc and iron rich (bio-fortified) wheat varieties namely AKAW-4627 and NIAW-1415 under irrigated conditions (4-5 times, particularly at crown root initiation, tillering, jointing, flowering, milk and dough stage) during November 2013 to February 2014. The seed materials were collected from PDKV Akola, MPKV, Rahuri and Maharashtra State Seeds Corporation - Mahabeej. The selected land area was split into two equal portions (1.5acres) which was further split into two in order to accommodate AKAW-4627 *Vs* local variety Narmada sagar and to accommodate NIAW-1415 *Vs* local variety Lok-1. The package of practices was consistent, irrespective of the varieties tested. Seeds were treated with Carbendazim 50WP @ 3g kg^{-1} seed for 24 hours prior to sowing. Uniform seed rate of 40 kg $acre^{-1}$ were used for sowing. The seeds were sown in lines or rows using bullock-drawn seed drill with 25 x 8cm spacing. The nutrient recommendation of 80:40:40 NPK Kg ha^{-1} was followed where full dose of P and K and fifty percent of N was applied as basal dose. The remaining fifty percent of N was applied as top dressing at 21 days after sowing (DAS).

Results:

The harvest results indicated that the mean grain yield for AKAW-4627 and NIAW-1415 were 3239kg ha^{-1} and 3594kg ha^{-1}, respectively while the mean grain yield of local varieties were of 1375kg ha^{-1}.

Study 2: Evaluating the performance of improved varieties of chick pea

Objective: to study the crop performance of improved varieties namely Jacki – 9218 and PKV-Kabuli under irrigated conditions.

Materials and methods:

An on farm demonstration with four selected farmers was undertaken in 1.25 acres of land area from November 2013 to March 2014 to study the crop performance of improved varieties namely Jacki – 9218 and PKV-Kabuli under irrigated conditions (2-3 times, during pre-flowering or flowering and at pod initiation/developing stage). Each known land area (0.3 ha) was divided into three equal portions in order to accommodate Jacki– 9218, PKV-Kabuli and farmers' local varieties. The package of practices was consistent, irrespective of the varieties tested.

The land was ploughed using bullock-drawn plough followed by harrowing with blade harrow to provide a fine tilth. Seeds were sown using bullock-drawn planter in lines or rows at 30x10cm spacing. Irrespective of varieties tested; seed rate of 75kg ha^{-1} was used for sowing. Improved agronomic practices mainly included seed treatment with Carbendazim 50WP @ 3g kg^{-1} seed 24 hours before sowing and recommended intercultural operations particularly; weeding and fertilizer applications. The recommended fertilizer dose of 25:50:30 NPK kg ha^{-1} was applied as basal dose. Weeds were checked manually at critical crop growth stages (i.e. first 4-6 weeks of crop growth).

Results:

Under the given soil and weather conditions, Jacki-9218 and PKV-Kabuli was found to produce mean grain yield of 2160kg ha^{-1} and 1916kg ha^{-1}, respectively. The obtained grain yields were 25-30% higher than the most farmers' varieties (e.g. Vijay, Himmat, Daftari).

Study 3: Assessing the performance of improved linseed variety

Objective: to study the crop performance of improved linseed variety-NL-260 under irrigated conditions.

Materials and methods:

This study was carried out with two selected farmers in 2 acres of land area from November 2013 to February 2014. The seed materials were collected from PDKV, Akola. Well decomposed farm yard manure (FYM) @ 5 t ha^{-1} was applied during last ploughing followed by harrowing to provide a fine tilth. The seeds were sown @ 25 kg ha^{-1} in lines or rows using manual seed driller with 22x10cm spacing and a planting depth of 2-3cm. Seeds were treated with Captan @ 2.5 per kg of seeds for 6 hours before sowing. A blanket recommended

fertilizer dose of 60:40:00 NPK kg ha^{-1} was adopted. Full dose of P and 50% N was applied at the time of sowing and the remaining 50% of N was applied at 35 DAS. Two irrigations were given; one at 30-40 days after sowing and the second just before flowering.

Results: The mean yield recorded was 496 kg ha^{-1}, 53 per cent higher than yield of usual farmers' varieties.

Study 4. Assessing the performance of improved mustard variety

Objective: to study the crop performance of improved mustard variety-Shatabdi under irrigated conditions.

Materials and methods:

The study was undertaken with five selected farmers covering an area of 5 acres from November 2013 to February 2014. Well decomposed farm yard manure (FYM) @ 5t ha^{-1} was applied during last ploughing followed by harrowing using blade harrow to provide a fine tilth. The seeds were sown @ 5 kg ha^{-1} in lines or rows using manual seed driller with 30x10cm spacing. Seeds were treated with Captan @ 2.5 per kg of seeds for 6 hours before sowing. A blanket recommended fertilizer dose of 80:40:40 NPK kg ha^{-1} was adopted. Full dose of P and K, and 50% N was applied at the time of sowing whereas remaining 50% of N was applied as a foliar spray. The mean yield recorded was 496kg ha^{-1}, 50 per cent higher than the average yield of local mustard varieties in the area. Two irrigations were provided one at 30 DAS or branching stage and other at 60 DAS or pod formation stage.

Results: The mean seed yield was reported to be 660kg ha^{-1}.

5.3.2. 2014 OFD

5.3.2.1.Kharif-2014 OFD

The OFDs in kharif 2014 were:

i. Evaluating the performance of desi cotton variety-Suraj
ii. Assessing the performance of improved variety of pigeon pea as sole/ inter crop
iii. Assessing the performance of improved variety of soybean
iv. Assessing the performance of improved variety of sorghum
v. Assessing the performance of improved variety of green gram as an intercrop

Study 1. Evaluating the performance of desi cotton variety-Suraj

Objective: To evaluate the yield performance of desi cotton variety- Suraj.

Materials and methods:

The package of practices followed was the same as reported under 5.3.1 (Study 1). The number of farmers increased from twenty to 30, covering an area of 30 acres.

Results:

On an average, cotton lint yield under this high density planting was 695 kg ac^{-1}.

Study 2: Assessing the performance of improved variety of pigeon pea as sole/ inter crop

Objective: to assess the yield performance of improved pigeon pea variety- PKV-Tara under both sole and intercropping with cotton.

Materials and methods:

An on farm demonstration was undertaken during June -December 2014 in thirty farmers' fields covering a total land area of 30 acres to evaluate the crop performance of improved pigeon pea variety- PKV-Tara. PKV-Tara is a high yielding; medium duration bold seeded variety and reported to be well suited for the local soil and weather conditions by PDKV, Akola. Under this study, six farmers had sole cropping of pigeon pea on 6 acres of land whereas rest intercropped it with cotton in the ratio of 2:6. A well decomposed farm yard manure @ 2-3 t ha^{-1} was applied during last ploughing, followed by harrowing in order to provide a fine tilth. The seeds were sown @ 5 kg ha^{-1} by dibbling method at the spacing of 60x20cm. Seeds were treated with Carbendazim 50WP @ 3g kg^{-1} seed prior to 24 hours of sowing.

Results:

Average seed yield was reported to be 700 and 425 kg ha^{-1} from sole cropping and intercropping plots, respectively.

Study 3: Assessing the performance of improved variety of soybean

Objective: to evaluate the yield performance of soybean improved variety-'N-15'.

Materials and method:

This study was undertaken in eleven farmers' fields covering a total land area of 11 acres from June - November 2014. A well decomposed farm yard manure (FYM) @ 5t ha^{-1} was applied and incorporated during last ploughing, followed by harrowing to provide a smooth soil surface. The seeds were sown @ 75 kg ha^{-1} by dibbling method with a spacing of

30x5cm. Seeds were treated with Thiram @ 3g kg^{-1} of seeds and *Trichoderma viride* @ 4g kg^{-1} of seeds prior to sowing.

Results:

The average seed yield was reported to be 1774 kg ha^{-1} (Yield affected by untimely rainfall)

Study 4: Assessing the performance of improved variety of sorghum

Objective: to evaluate the yield performance of sorghum improved variety-NJH-40-Ratna.

Materials and methods:

The study was carried out in seventeen farmers' fields from June to November 2014 covering an area of 17 acres. A well decomposed farm yard manure (FYM) @ 5 t ha^{-1} was applied and incorporated during last ploughing, followed by harrowing to provide a smooth soil surface. The seeds were sown @ 7.5 kg ha^{-1} with manual seed driller at 30x10cm spacing. Besides, seeds were treated with Carbendazim 50WP @ 3g per kg seed for 24 hours before sowing. A blanket recommendation of 90:45:45 NPK kg ha^{-1} was adopted. Full P and K and 50% N were applied at the time of sowing. The remaining 50% N was applied as two split dose at 15 and 30 days after sowing.

Results:

The average seed and straw yield was reported to be 994 and 4053 kg ha^{-1}, respectively.

Study 5: Assessing the performance of improved variety of green gram as an intercrop

Objective: to evaluate the yield performance of green gram improved variety Naval-1 as an intercrop with cotton in a ratio of 2: 6.

Materials and methods:

The study was carried out in 29 farmers' fields from June to September 2014 covering an area of 29 acres. A well decomposed farm yard manure (FYM) @ 5 t ha^{-1} was applied and incorporated during last ploughing, followed by harrowing to provide a smooth soil surface. The green gram seeds were sown @ 2.5 kg ha^{-1} with manual seed driller at 30x10cm spacing in between cotton rows. Besides, seeds were treated with Carbendazim 50WP @ 3g per kg seed for 24 hours before sowing.

Results:

Out of 29 farmers, only 15 had a good crop stand and recorded an average seed yield of 420 kg ha^{-1}. Rest of the farmers witnessed crop damage due to poor germination.

5.3.2.2.Rabi-2014 OFD

The OFDs in rabi 2014 were:

i. Assess the performance of nutrient-dense and high yielding wheat varieties
ii. Assess the performance of improved varieties of chickpea

Study 1: Assess the performance of nutrient-dense and high yielding wheat varieties

Objective: To assess the yield performance of zinc and iron rich (bio-fortified) wheat varieties namely AKAW-4210 and NIAW-1415 and also high yielding and early maturing (120-135 days) variety namely GW-496 under irrigated conditions.

Materials and methods:

The study was carried out in twenty seven farmers fields during November 2014 to February 2015 where the crop performance of zinc and iron rich (bio-fortified) wheat varieties *viz.,* AKAW-4210 and NIAW-1415 and also high yielding and early maturing (120-135 days) variety namely GW-496 was assessed under irrigated conditions (4-5 times, particularly at crown root initiation, tillering, jointing, flowering, milk and dough stage). The seed materials were collected from PDKV Akola, MPKV, Rahuri and Mahabeej.

Ten farmers covering a total land area of 10acres tested AKAW-4210. Each selected land area was split into two equal portions to accommodate AKAW-4210 *Vs* local variety Narmada sagar whereas seventeen farmers covering a total land area of 17 acres tested GW-496. The known portion of land area included GW-496 *Vs* local variety 'Eagle'. Further, only one farmer field having 1 acre was split into 0.5 acre for NIAW-1415 *Vs* local variety Lok-1. The package of practices was consistent, irrespective of the varieties tested.

Seeds were treated with Carbendazim 50WP @ 3g per kg seed for 24 hours prior to sowing. The seeds were sown @ 40 kg ac^{-1} in lines or rows using bullock-drawn seed drill at 25 x 8cm spacing. The nutrient recommendation of 80:40:40 NPK Kg ha^{-1}. Full dose of P and K and fifty percent of N was applied before sowing whereas remaining fifty percent of N was applied as top dressing at 21 days after sowing (DAS).

Results:

The average grain yield of AKAW-4210 and GW-496 was reported to be 71 and 17 per cent higher when compared to the local varieties Narmada sagar (1005 kg ha^{-1}) and Eagle (724 kg ha^{-1}), respectively.

Study 2: Assessing the performance of improved varieties of chick pea

Objective: to study the crop performance of improved varieties namely Jacki – 9218 under irrigated conditions.

Materials and methods:

An on farm demonstration with fifteen selected farmers was undertaken in 15 acres of land area from November 2014 to March 2015 to study the crop performance of improved varieties namely Jacki – 9218 under irrigated conditions (2-3 times), during pre-flowering or flowering and at pod initiation/developing stage). Each known land area was divided into two equal portions in order to accommodate Jacki– 9218 and farmers' local varieties. The package of practices was consistent, irrespective of the variety tested.

The land was ploughed using bullock-drawn plough followed by harrowing with blade harrow to provide a fine tilth. Seeds were sown using bullock-drawn planter in lines or rows at 30x10cm spacing. Irrespective of varieties tested; seed rate of 75kg ha^{-1} was used for sowing. Improved agronomic practices mainly included seed treatment with Carbendazim 50WP @ 3g kg^{-1} seed 24 hours before sowing and recommended intercultural operations particularly; weeding and fertilizer applications. The recommended fertilizer dose of 25:50:30 NPK kg ha^{-1} was applied as basal dose. Weeds were checked manually at critical crop growth stages (i.e. first 4-6 weeks of crop growth).

Results:

Under the given soil and weather conditions, Jacki-9218 was found to produce mean grain yield of 1273 kg ha^{-1}. The obtained grain yields were 16 per cent higher than most farmers' varieties (e.g. Vijay, Himmat, Daftari).

5.3.3 2015 OFD

Building on the learnings from the OFD trials in 2013 and 2014 and with the baseline information regarding the nutrition status of the community in hand, detailed discussions were held with community members, to plan the crop trials in kharif and rabi 2015.

5.3.3.1 Kharif-2015 OFD

The following trials were undertaken in Kharif:

i. Evaluating the performance of three desi cotton varieties (Suraj, NH-615 & Phule Dhanwantary)
ii. Assess the performance of improved variety of pigeon pea as sole crop

iii. Assess the performance of improved variety of pigeon pea and green gram as intercrop

iv. Improved production practices of sorghum

Study 1: Evaluating the performance of three desi cotton varieties (Suraj, NH-615 & Phule Dhanwantary)

Objective: To evaluate the yield performance of three desi cotton varieties namely Suraj, NH-615 and Phule Dhanwantary.

Materials and methods:

The study was undertaken in thirty five selected farmers' fields covering 7 ha area from April to December, 2015. The desi varieties are of early maturing and short duration, and often recommended under high density planting to compensate for fewer pickings. Although, high density planting incurs more seeds, the seed cost is considerably less, as compared to Bt hybrids.

Thirty five farmers' with 7ha land area tested Suraj. NH-615 was sown by 14 farmers' covering 2.8ha and Phule Dhanwantary was tested with 10 farmers in about 2.0ha of land area. A well decomposed farm yard manure (FYM) @ 2-3 t ha^{-1} was applied and ploughed in or incorporated using bullock-drawn plough, and followed by harrowing using blade harrow to break up clods and to provide a fine tilth. The seeds were sown by dibbling method at 45x10 cm to maintain optimum plant population and also to accommodate pigeon pea as an intercrop in 6:2 ratio. Seed rate of 10 kg ha^{-1} was used for all three desi types.

A blanket recommendation of NPK @ 80:40:40 kg ha^{-1} was adopted. Full dose of P and K was applied before sowing whereas fifty percent of N was applied 15-20 days after sowing (DAS) and the remaining fifty percent was applied 40-60 DAS. First Hoeing was performed at 20-30 DAS whilst, second was performed during 45-60 DAS. Prior to hoeing, pre-emergence application of Pyrithobac Sodium 10 % EC (Hit-weed herbicides) @ 1 lit ac^{-1} was sprayed to control weed emergence. To reduce the pest pressure from Aphids and Jassids, systemic insecticides like Monochrotophos, Shotgun, Spinctor or fame was advised @20-30 ml per10 liter of water during the square formation stages.

Critical assessments included: 1. *Plant counts* by counting number of plants using a quadrat randomly placed with five replications. 2. *Plant heights* were measured by metre rule. 3. *Number of bolls per plant*, bolls from 5-10 plants was selected randomly from the net plot and the average number of bolls per plant was estimated. At final maturity, kapas was

removed from well burst bolls and shade dried. Agronomic data for the three varieties is given in Table 9.

Table 9. Yield parameters and fiber yield* of cotton

	Suraj (n=35)	NH-615 (n=14)	P.Dhan. (n=10)	Crop stages
Plant populations (m^2)	7	8	6	After germination
Plant heights (cm)	102	119	67	Boll formation
Number of bolls/plant	15	21	6	Boll formation
Fiber yield (kg ha^{-1})	461	475	293	After picking

**mean values reported*

Results:

Under the given soil and weather conditions, the performance of desi varieties ranked in the order of NH-615 > Suraj > Phule Dhanwantary. In general, the yields from desi varieties under rain-fed conditions were less, as compared with high input and high output Bt cotton hybrids from neighboring farmers' field. However, *desi* varieties required lower chemical inputs and also reduced cost of cultivation. Typically, Bt growers use twice the nutrient dose (120:60:60 NPK kg ha^{-1}), additional spray of pesticides and water supply/irrigation to achieve higher yields. Further, in case of desi varieties, the seeds can be retained to be used in the next cropping season.

Study 2: Improved production practices of pigeon pea

Objective: To assess the performance of improved pigeon pea variety NTL-900.

Materials and methods:

The performance of sole cropping of improved pigeon pea variety NTL - 900 was studied with farmer's local varieties such as Yashoda, Ganesh, and Daftary under improved cultivation practices. On farm trials were undertaken in twenty two farmers' fields covering a total land area of 8.8ha from 28 April 2015 - 15 January 2016.

Each farmer's field was split into two equal portions to include recommended variety and farmers' local varieties. The land was prepared to a fine tilth and about 5-7 t ha^{-1} of farm yard manure (FYM) was applied at the time of last ploughing. Seeds were treated with Carbendazim 50WP @ 3g per kg seed 24 hours before sowing. Seed rate of 15kg ha^{-1} were used for sowing. The seeds were sown by dibbling method with 60 x 60 cm spacing. The nutrient recommendation of 25:50:30 NPK kg ha^{-1} was followed as top dressing after seed

germination. Manual weeding was performed twice at 20-25 DAS and at 50-60 DAS. To control pest attacks, particularly, pod borer, contact insecticides like Fem, Shooter or Awant @ 5-10 ml/10 liters of water was sprayed.

Critical assessments included: 1. *Plant establishment* by counting number of plants using a quadrat randomly placed with five replications. 2. *Plant heights* were measured by metre rule. 3. *Number of pods per plant*, pods of 5-10 plants selected randomly from the net plot was counted and the average number of pods per plant was estimated. The harvested plants by quadrat were threshed, sun dried, and cleaned to record the yield. Yield performance of the tested varieties is given in Table 10.

Table 10. Yield parameters and grain yield* of pigeon pea

	NTL(900) (n=22)	Farmers (n=22)	Crop stages
Plant establishment (m^2)	14	14	After germination
Plant heights (cm)	166	167	During pod formation
Number of pods per plant	69	53	During pod formation stage
Yield (kg/ha)	1532	1461	Complete maturity
1000 seeds weight(g)	102	102	Complete maturity

**mean values reported*

Results:

Under the given soil and weather conditions, the yield of improved variety was found to be superior, compared to farmers' local varieties. In addition, the duration of improved variety was 150-160 days, compared to most farmers' local varieties (180-200 days). Pigeon pea economics is given in Table 11.

Table 11. Economics of pigeon pea production

Particulars	**NTL-900**	**Farmers varieties**
Total cost of cultivation (Rs./ha)	25070	25070
Total Production (Kg./ha)	1533	1460
Market Price(Rs/Kg)	80.00	80.00
Gross return (Rs/ha)	1,22,600	1,16,800
Net return (Rs/ha)	65,528	49,715

Study 3: Assess the performance of improved variety of pigeon pea and green gram as intercrop

Objective: To evaluate the performance of improved varieties of pigeon pea and green gram as intercrop with cotton in 2:6 ratio.

Materials and methods:

An on farm demonstration was undertaken during June -December 2015 to evaluate the crop performance of improved pigeon pea variety- NTL-900 (from Nirmal seeds) and green gram variety iskopargaon intercropped with cotton in the ratio 2:6. Each intervention was carried out in 25 farmers' fields covering a total land area of 25 acres. Well decomposed farm yard manure @ 5 t ha^{-1} was applied during last ploughing, followed by harrowing in order to provide a fine tilth. The pigeon pea seeds were sown @ 5 kg ha^{-1} by dibbling method at the spacing of 60x30 cm whereas green gram seeds were sown @2.5 kg ha^{-1} with a spacing of 30x15 cm. Seeds were treated with Carbendazim 50WP @ 3g kg^{-1} seed prior to 24 hours of sowing.

Results:

The harvest results reported Pigeon pea variety NTL-900 and green gram variety iskopargaon had an average seed yield of 1313 and 554 kg ha^{-1}.

Study 4: Improved production practices of sorghum

Objective: To evaluate the performance of improved dual purpose sorghum variety CSV-20.

Materials and methods:

Timely unavailability of good quality hybrid sorghum seeds motivated farmers to test improved sorghum variety recommended by PDKV, Akola as there was possibility of seed retention for the next cropping season. The performance of late Kharif advanced sorghum dual purpose variety CSV-20 was studied with forty one farmers covering a land area of 16.4 ha from May to November 2015.

The land was prepared to fine tilth and about 8-10 t ha^{-1} of farm yard manure (FYM) was applied at the time of last ploughing. Seeds were treated with Carbendazim 50WP @ 3g per kg seed for 24 hours before sowing. Seed rate of 7.5 kg ha^{-1} were used for sowing. The seeds were sown in lines or rows using bullock-drawn seed planter with 30 x 10cm spacing. The nutrient recommendation of 80:40:40 NPK Kg ha^{-1}. Full dose of P and K and fifty percent of N was applied as basal dose whereas remaining fifty percent of N was applied as top dressing at 30 days after sowing (DAS). Manual weeding was performed twice at 20-30 DAS and at 40-60 DAS.

Critical assessments included: 1. *Plant establishment* by counting number of plants using a quadrat randomly placed with five replications. 2. *Plant heights* were measured by metre rule. The harvested plants by quadrat were mechanically threshed and the grain yield and thousand seed weight was recorded. Field and yield performance of CSV-20 is given in Table 12.

Table 12. Yield parameters and grain yield* of sorghum (CSV-20)

	CSV-20	Crop stages
Plant population (1x1 m^2)	28	Head initiation stage
Plant heights in (cm)	229	At maturity
Yield (kg/ha)	330	After threshing
1000 grain weights in (gm)	39.28	After threshing

**mean values reported*

Results:

The average yield of CSV-20 was reported to be 320 kg ha^{-1}, 33 per cent lower as compared to most of the popular farmers' hybrids *viz.,* CSH-9, Mahagujrat, and Annapurna (average yield of 479 kg ha^{-1}). However, retention of seeds and their recurrent use will not only avert the risk of timely availability of seeds but also reduce cost of cultivation in future cropping seasons.

5.3.3.2 Rabi-2015 OFD

The OFDs during rabi 2015 were as follows:

The trials during the rabi season covered:

i. Improved production practices of chickpea
ii. Assessing performance of nutrient dense wheat varieties
iii. Improved production practices of onion

Study 1: Improved production practices of chick pea

Objective: To study the performance of improved variety Jacki – 9218, which is resistant to wilt and root rot against farmers' local varieties (Daftary, Vijay, Vishal, Himmat) under improved agronomic practices.

Materials and methods:

On farm demonstration was carried out with twenty selected farmers in 8ha of land area from September 2015 to February 2016. Each known land area was divided into two equal portions to accommodate recommended variety and farmers' local varieties. The land

was ploughed using bullock-drawn plough followed by harrowing with blade harrow to provide a fine tilth. Seeds were sown using bullock-drawn planter in lines or rows with 30x10cm. Irrespective of varieties tested, seed rate of 30 kg ac^{-1} was used for sowing. Improved agronomic practices mainly included seed treatment with Carbendazim 50WP @ 3g per kg seed 24 hours before sowing and with recommended intercultural operations particularly weeding and fertilizer applications. The recommended fertilizer dose of 25:50:30 NPK kg ha^{-1} was applied as basal dose. Weeds were checked manually at critical crop growth stages (first 4-6 weeks of crop growth). To control pest infestation, particularly, gram pod borer, systemic insecticides like Chlorpyriphos, Shotgun or Spinctor was advised @20-30 ml per10 liter of water and was applied as a precautionary measure during flowering stage and at pod formation. Two irrigations were given; one during pre-flowering or flowering and another at pod initiation/developing stage.

Critical assessments included: 1. *Plant establishment* by counting number of plants using a quadrat randomly placed with five replications. 2. *Plant heights* were measured by metre rule. 3. *Number of pods per plant*, pods of 5-10 plants selected randomly from the net plot was counted and the average number of pods per plant was estimated. The harvested plants by quadrat were threshed, sun dried, and cleaned to record the thousand seed weight and seed yield (Table 13).

Results:

Under the given soil and weather conditions, the yield of Jacki – 9218 was found to be 15% higher than the farmers' varieties (782 kg ha^{-1}). The chickpea economics is given in Table 14.

Table 13. Comparison of yield parameters and grain yield* between Jackie-9218 and farmers varieties in chickpea

	Jacki-9218	Farmers varieties	Crop stages
Plant establishment (2x2m²)	57	52	After germination
Plant heights (cm)	44	43	During pod formation
Number of pods per plant	46	43	During pod formation stage
Yield (kg/ha)	897	782	Complete maturity
1000 seeds weight(g)	184	182	Complete maturity

**mean values reported*

Table 14. Economics of production of chickpea

Particulars	Jacki-9218	Farmers varieties
Total cost of cultivation(Rs./ha)	23124.00	23124.00
Total Production (Kg./ha)	897.00	782.00
Price(Rs/Kg)	55.00	55.00
Gross return (Rs/ha)	49335.00	43010.00
Net Profit (Rs/ha)	26211.00	19886.00

4.3.2 Study 2: Improved production practices of onion

Objective: To assess the performance of improved variety (Bhima super) against farmers' popular variety (Baswant - 780) under improved cultivation practices.

Materials and methods:

The study was undertaken in the selected farmers' fields with 19 farmers' covering land area of 1.9ha from October 2015 to March 2016. Onion seedlings were raised on nursery beds of 10cm high. The seed rate @10-12 kg ha^{-1} was used for sowing. Seedlings of 30-40 days old were transplanted in the main field.

Each farmers' field was split into two equal portions to transplant Bhima super and Baswant – 780. The field was ploughed and harrowed to break up clods and to provide smooth surface or fine tilth. The recommendation for nutrient application was 10:26:26 NPK kg ha^{-1}. Full dose of N, P and K was applied as top dressing 30 days after transplanting. Manual weeding was performed twice at critical crop growth stages. Surface irrigation was given at weekly intervals, sufficient irrigation at bulb forming stage; however, watering was stopped 20-25days prior to maturity to improve keeping quality of bulbs. To reduce thrips attack, Propenophos @ 20 ml per 15 liter of water was sprayed.

Results:

Under improved cultivation practices, it was observed that the onion yield and net return under Bhima super was 94 and 168 per cent higher, respectively as compared to Baswant – 780 (Table 15).

Table 15. Economics of onion production

Particulars	Bhima super	Baswant-780
Total cost of cultivation (Rs/ha)	21500	21500
Total Production (Kg./ ha)	6320	3260
Price(Rs/Kg)	15.00	15.00
Gross return (Rs/ha)	94800	48900
Net return (Rs/ha)	73300	27400

Study 3: Performance of nutrient-dense wheat varieties

Objective: To assess the performance of zinc and iron rich (bio-fortified) wheat variety namely AKAW-4210.

Materials and methods:

During Rabi 2015-16, the performance of zinc and iron rich (bio-fortified) wheat variety namely AKAW-4210 was studied with thirty five farmers covering an area of 14 ha. Each farmer's field was split into known portions to accommodate improved micro-nutrient rich wheat variety and farmers' local varieties (Lok-1, Narmada Sagar and Eagle) under improved cultivation practices.

The selected land area was prepared to fine tilth. Seeds were treated with Carbendazim 50WP @ 3g per kg seed for 24 hours before sowing. The seeds were sown @ 100 kg ha^{-1} in lines or rows using bullock-drawn seed drill with 25 x 8cm spacing. The nutrient recommendation of 80:40:40 NPK Kg ha^{-1} was followed where full dose of P and K and fifty percent of N was applied as basal dose and remaining fifty per cent of N was applied as top dressing at 21 days after sowing (DAS). Four-five irrigation was given; particularly at crown root initiation, tillering, jointing, flowering, milk and dough stage.

Critical assessments included: 1. *Shoot number* by counting number of main stem + tillers using a quadrat randomly placed with five replications. 2. *Plant heights* were measured by metre rule. The harvested plants by quadrat were threshed and thousand seed weight and the grain yield was recorded (Table 16).

Results:

Under given soil and weather conditions, the yield of AKAW- 4210 was 15-20% higher than farmer's varieties (1322 kg ha^{-1}). Wheat economics is given in Table 17.

Table 16. Comparison of yield parameters and grain yield* between AKAW-4210 and farmers' varieties of wheat

	AKAW-4210	Farmers Varieties	Crop stages
Shoot numbers (m^2)	879	800	At stem elongation
Plant heights (cm)	77	75	At maturity
1000 seed weight (g)	42	40	At maturity
Yield (kg/ha)	1560	1322	At maturity

**mean values reported*

Table 17. Economics of wheat production

Particulars	AKAW-4210	Farmers varieties
Total cost of cultivation (Rs./ha)	22980	22980
Total Production (Kg./ ha)	1560	1322
Price(Rs/Kg)	18.00	18.00
Gross return (Rs/ha)	28080	23805
Net return (Rs/ha)	5100	825

5.4. Others

Despite many efforts, some of the OFDs failed during the course of implementation, either due to attack of wild animals (nilgai, boar) or insufficient or excess rainfall causing complete crop damage: iron fortified pearl millet and maize in Kharif 2013 and 2014; sorghum and maize in Rabi 2013-14; and maize, linseed, sorghum and groundnut in Rabi 2014-15.

6. Conclusion

To address the nutrition and agricultural challenges, increased land acreage of household food security crops with improved varieties of seeds and improved practices were attempted. Nutrient-dense crops like pulses, wheat and sorghum acreage was increased (either as sole or intercrop). In addition, alternative cropping practices with desi cotton varieties were piloted as an alternative to high-input based Bt cotton. Improved variety of sorghum other than existing hybrid sorghum and desi cotton varieties other than existing Bt cotton had lower yields. The lower yields can possibly be compensated by reduced cost of cultivation and also ability to retain the seed for use in the next season. Soybean crop was affected in both the years due to untimely rainfall; however, as there is no local consumption preference for soybean, further effort was not made in that direction. Oilseed crops, mustard and linseed

were tried out in one year. Not being food crops, there is need for developing the market and value chain to help farmers realize their potential. The improved varieties of pigeon pea, wheat and chickpea performed well in all years. Onion, a widely consumed vegetable was tried out for the first time in 2015-16 at farmers expressed request and performed well.

It was also learnt that some cropping systems such as inter cropping of cotton with green gram or pigeon pea was well received by farmers in the area as pulses ensured yield security in case the main crop (i.e. cotton) failures as well as being an important component of their daily diet. Similarly, even though sorghum crop was prone to damage by birds and wild animals, farmers were willing to grow it as it is one of the staple crops of the area. In this context, careful selection of varieties with respect to their duration (in order to avoid climatic stress) and potential yield as well as crop management measures such as timely sowing, weeding and integrated pest management etc were considered to be taken care of during upcoming cropping seasons. Additionally, it was also found that the particular agroclimatic region was not suitable for bajra and QPM maize. In case of linseed, even though the demonstration failed initially, considering reports of growing the crop in nearby areas as well as its nutritional importance, efforts will be made in order to popularize the same in our study areas.

7. Way forward

Though unpredictable weather did play a major role, in general, most crop-based FSN interventions had positive impacts of introducing household food security crops. As intended, the study approach helped farmers understand and witness the superiority of proposed practices through their involvement and *in situ* environment. This in turn helped diffusion of knowledge and practices to more farmers. The exercise helped build rapport, gain farmers confidence and also to a certain extent instill a nutrition focus in their thinking

Key interventions were identified from among all the demonstrated crop-based FSN interventions through farmers expressed interests for upscaling in 2016-17 - For kharif 2016, pigeon pea (sole crop in 143ac and intercropping with cotton in 57ac); green gram (sole crop in 37ac and intercropping with red gram in 28ac); improved production practices of sorghum (200 ac). Similarly for *rabi* 2016, gram (26ac), wheat (18ac) and onion (1ac) are underway in the study site.

References

1. Das PK, Bhavani, RV & Swaminathan MS. (2014). A farming system model to leverage agriculture for nutritional outcomes. *Agricultural Research,* 3(3), 193-203.
2. Government of India - GoI (2011). Census of India 2011. Office of the Registrar general and Census Commissioner
3. Government of India (2016). District Fact Sheet Wardha. Maharashtra. National Family Health Survey 2015-16. Indian Institute for Population Sciences and Ministry of Health and Family Welfare
4. Government of Maharashtra-GoM. (2005). District wise Agricultural Data Base for Maharashtra.
5. Government of Maharashtra-GoM. (2006). Maharashtra Gazetteer: Wardha District, (e-book edition).
6. Masset, E., Haddad, L., Cornelius, A., & Isaza-Castro, J. (2011). A systematic review of agricultural interventions that aim to improve nutritional status of children. London: EPPI-Centre, Social Science Research Unit, Institute of Education, University of London.
7. MSSRF. (2010). Designing Rural Technology Delivery Systems for Mitigating Agricultural Distress – A Study of Wardha District. M..S. Swaminathan Research Foundation, Chennai.
8. Nagarajan S, Bhavani RV & Swaminathan MS. (2014). Operationalizing the concept of farming system for nutrition through the promotion of nutrition-sensitive agriculture, *Current Science,* 107 (6), 959-964.
9. World agricultural census. (2000-01). Available at: www.agcensus.nic.in
10. World Bank. (2007). From Agriculture to Nutrition: Pathways, Synergies and Outcomes. Agriculture and Rural Development Department, Washington DC. Available at: http://siteresources.worldbank.org/INTARD/825826111134598204/21608903/January2008Final.pdf (accessed 21 August 2016).

Annexure I

Details of implemented OFDs under FSN during cropping period (2013-15)

Season	OFDs	Existing varieties/ technology	Introduced technology	No. of farmer (s)	Total area under OFD (ac)	Introduced technology	No. of farmer (s)	Total area under OFD (ac)	Introduced technology	No. of farmer (s)	Total area under OFD (ac)
			2013(varietal substitution)			2014 (varietal substitution + change in cropping pattern)			2015 (varietal substitution + change in cropping pattern)		
Kharif	cotton	Ankur, Mallika BG-2, Jay Bt	Early maturing CICR recommended new desi variety "suraj" under high density planting	20	20	CICR recommended variety "Suraj"	30	30	three desi cotton varieties namely Suraj, NH-615 and Phule Dhanwantary.	35	7
	Cotton + pigeon pea (6:2)	Ganesh, Daftari	assess the yield performance of improved pigeon pea variety in intercropping- 'Durga'	15	15	Both sole and intercropping of PKV-Tara	30	30	Sole cropping of NTL-900	22	8.8
	Soybean	JS-335, Kalasona, Heera moti	N-15	10	10	N-15	11	11	N-15	10	10
	Sorghum	CSH-09, 05, 540 Annapurna Sona -27				NJH-40-Ratna	17	17	CSV-20	41	16.4
Rabi	Wheat	Narmada Sagar LOK-1	Zinc and iron rich variety of wheat AKAW-4627 and NIAW-1415	6	3	Zinc and iron rich variety of wheat AKAW-4627 and NIAW-1415	27	27	Zinc and iron rich variety of wheat AKAW-4627 and NIAW-1415	35	35
	Chick pea	Vijay Daftari Vishal Himmat	Jacki – 9218 and PKV-Kabuli	4	1.25	Jacki – 9218 and PKV-Kabuli	15	15	Jacki – 9218	20	8
	Linseed	-	*NL-260	2	2						
	Mustard	-	*Shatabdi	5	5						
	Onion	Baswant-780							Bhima Super	19	1.9

Annexure II

Nutrition composition of major food crops promoted through FSN crop based interventions

Crop	Protein (g)	Total fat (g)	Dietary fibre (g)	Carbohydrate (g)	Energy (KJ)	Calcium (mg)	Phosphorous (mg)	Iron (mg)	Total Folates (µg)
Sorghum	9.97	1.73	10.22	67.68	1398	27.60	274	3.95	39.42
Green gram, dal	23.88	1.35	9.37	52.59	1363	43.13	416	3.93	92.11
Green gram, whole	22.53	1.14	17.04	46.13	1229	92.43	353	4.89	145
Pigeonpea, dal	21.70	1.56	9.06	55.23	1384	71	328	3.9	108
Pigeon pea, whole	20.47	1.38	22.84	42.48	1146	139	312	5.37	229
Sweet potato	1.27	0.33	3.94	23.93	452	28.93	37.60	0.51	22.20
Wheat flour	10.57	1.53	11.36	64.17	1340	30.94	314	4.10	29.22
Bengal gram dal	21.55	5.31	15.15	46.72	1377	46	375	6.08	182
Bengal gram whole	18.77	5.11	25.22	39.56	1201	150	345	6.78	233
Onion	1.5	0.24	2.45	9.56	201	21.03	32.34	0.43	28.88

(All values are expressed per 100 gm of edible portion)

*(**Source:** Indian Food composition tables, 2017, NIN, Hyderabad)*