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Smallholder Farming and Crop Variety Choice: Wheat Variety Choice in Pakistan

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This brief is a summary of the 2012 HarvestPlus varietal adoption background study report titled “Farmers’ Choice of Wheat Varieties in Punjab, Pakistan,” by Hina Nazli, Dorene Asare-Marfo, Melinda Smale, Sohail Jehangir Malik, and Ekin Birol. The authors would like to thank Emily McNulty for her support in developing this brief from the main report. Portions of this brief are direct extractions from the main report, which is available from HarvestPlus upon request.

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I. INTRODUCTION

Zinc is an important nutrient for human health, especially for the growth of children (Caulfield and Black 2004). In 2011 Pakistan's National Nutrition Survey found that zinc deficiency is high (47 percent) among children under-five years of age and women of child-bearing age. Nearly 42 percent of non-pregnant women, 48 percent of pregnant women, and 37 percent of children are estimated to be zinc deficient. One promising strategy for increasing these populations' zinc intake is through biofortification of their most commonly consumed staple crop, wheat, with zinc. According to the biofortification prioritization index (BPI), Pakistan ranks fifth among developing countries as a suitable target for high-zinc wheat biofortification (Asare-Marfo et al. 2013).

HarvestPlus and its partners are using conventional breeding methods to develop wheat varieties that are rich in zinc. These varieties, expected to be officially released in 2015, should provide 60 percent of daily zinc needs for women and children, 20 percent more than commonly grown varieties, and will offer other desirable traits such as high yields and disease resistance. The delivery and marketing activities for these varieties will start once the varieties are released. In order to help inform effective and targeted delivery and marketing plans, and to later monitor adoption trends, HarvestPlus and its partners conducted a varietal adoption study in 2011, which involved a survey of farm households in Punjab and examined current trends in wheat cultivation and consumption. This paper summarizes the key findings of that study and makes recommendations for delivery and marketing of high-zinc wheat varieties to achieve maximum adoption and consumption impact among the most vulnerable populations.

II. METHODOLOGY & SURVEY IMPLEMENTATION

The varietal adoption survey was conducted among wheat farmers in Punjab. Punjab is Pakistan's largest province, where 76 percent of the country's wheat is grown (GOP 2011) and was the wheat epicenter of the Green Revolution in the 1960s and 70s. There are five agro-climatic/cropping zones in Punjab: the cotton-wheat zone, the rice-wheat zone, the mixed zone, the low intensity zone, and the barani (rain-fed) zone. The cotton-wheat zone, the rice-wheat zone, and the mixed zone were chosen for the study as these well-irrigated areas are the most popular for wheat cultivation. These zones also have historical significance as they were suitable sites for initial adoption of improved varieties during the Green Revolution.

A two-stage stratified cluster sampling design was used for the survey. In the first stage of sampling, revenue villages (villages classified as low, middle or high income by the Pakistan Bureau of Statistics and based on living standards of the majority of the people in the village) were allocated proportionately across the three agro-climatic zones based on the share of total wheat land area: 41 percent of revenue villages were selected from the cotton-wheat zone, 32 percent from the rice-wheat zone, and 27 percent from the mixed zone. This proportionate allocation gives a self-weighted sample that is representative of wheat production in Punjab. A systematic probability proportionate to estimated size (PPeS) approach was used for the selection of revenue villages (clusters) within each agro-climatic zone (stratum) using secondary data on the population size (total number of households) of each revenue village. In the second stage, 18 households were selected for each revenue village—12 officially selected for interviewing and 6 replacements in the event that one or more of the officially selected were unavailable or unwilling to participate in the survey.

The study's survey, Farmers' Choice of Wheat Varieties in Punjab, Pakistan, was implemented following the 2011 wheat harvest, and the structured questionnaires covered the two preceding cropping seasons: Kharif (rainy season) May to November 2010 and Rabi (dry season) October 2010 to May 2011. Survey instruments were developed in collaboration with agricultural experts in Pakistan, as well as at HarvestPlus/International Food Policy Research Institute (IFPRI) and Michigan State University. The farm household questionnaire included modules on household characteristics, land utilization, wheat cultivation, food frequency, sources of agricultural information, expenditures, income, assets, agricultural credit, prices, and seeds. A choice experiment was also carried out in this study and a module was dedicated to it in the household questionnaire. A community-level instrument was also implemented to collect information specific to a respective revenue village (e.g., distance to major road, rental rates of farm machinery, wage rates for male and female labor, popular wheat varieties in the village).

Thirty enumerators conversant in the local languages and local terminology were employed. They were trained over one week and conducted pre-tests of the questionnaires prior to the launch of the survey. There were five survey teams, each consisting of six enumerators and one supervisor. Team supervisors were responsible for field logistics which included securing interviews and assigning enumerators accordingly. They were responsible for conducting the community-level surveys. Data entry and cleaning immediately followed data collection.

III. RESULTS

A. Household Characteristics

Household characteristics of the sampled wheat farmers are reported in Table 1. The difference in the average age and average amount of farming experience of the household head is statistically significantly different across agro-climatic zones but not to a meaningful extent (therefore t-tests are not explicitly reported). Nearly 80 percent of respondents speak Punjabi as their native language, and almost all are Muslim and have been living in their respective villages for more than 10 years. The head of the household is the main decision maker in almost all the questions related to the production, storing, and marketing of wheat. However, as expected, the main decision maker for what is cooked in the home is the household head's spouse.

Across the three agro-climatic zones and in the two growing seasons, an average wheat farmer cultivates about 13 acres of land. Most of the plots under wheat cultivation are either owned (79 percent) or rented (19 percent); sharecropped plots are uncommon. Figure 1 shows the distribution of different farm sizes¹ in the three agro-climatic zones.

On average across farm sizes, farm income makes up almost 67 percent of total income. However, when farmers are disaggregated by farm size, it is revealed that marginal farmers derive less of their total income from farm activities

as they are involved in non-farm enterprises and earn wages from other work. Very few large-scale farmers are involved in non-farm, income-earning activities. Farmers grow and sell a variety of other crops, including fodder (grown by 78 percent of farmers), sorghum (61 percent), sugarcane (52 percent), rice (48 percent), and cotton (47 percent). Sugarcane and cotton have high sales values.

Most farmers own land (93 percent of total farmers), a house (99 percent), and a cell phone (90 percent). Livestock is common for draught, meat, or milk; bicycles (41 percent) and motorcycles (73 percent) are the most popular forms of transport. Large farmers have significantly more valuable assets than marginal farmers.

B. Varietal Adoption

Most farmers seem open to cultivating new wheat varieties. Results from the survey reveal that 90 percent of the farmers had cultivated a new variety at some point in the five years preceding the survey. Additionally, almost one-third of farmers grew more than one variety in the last season, either as an experiment (51 percent), to minimize risk (34 percent), or because different varieties serve different purposes (15 percent).

Table 2 shows the top eight varieties of wheat and their prevalence. Seher-06 appears to be the most popular wheat variety in Punjab, planted by 67 percent of farmers and covering 55 percent of plots in the sample. In 2011, it

Table 1: Household Characteristics of Wheat Farmers by Agro-climatic Zone

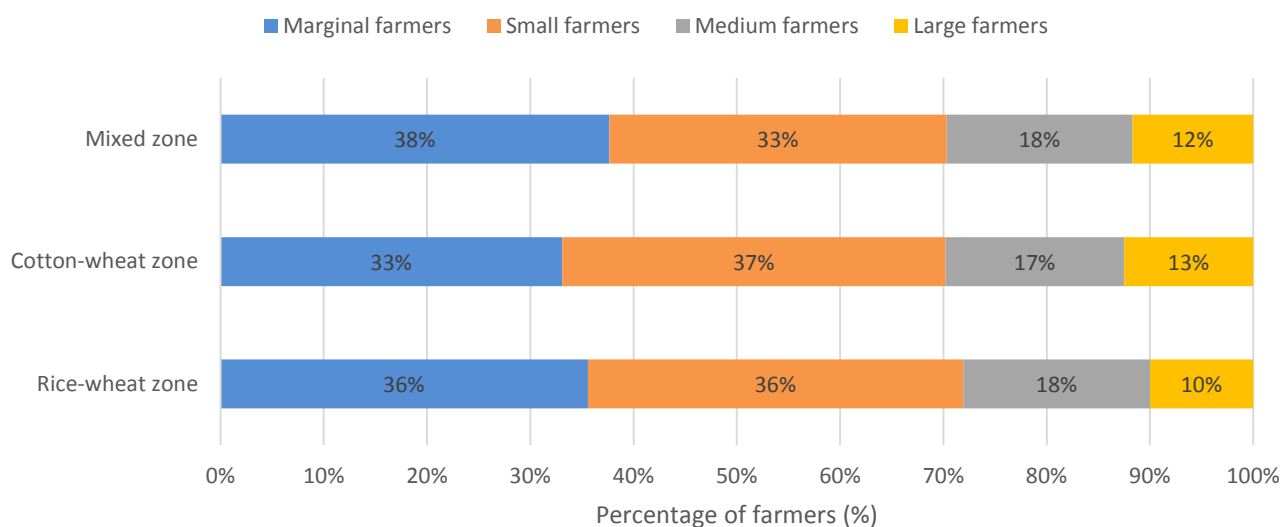
	Rice-wheat zone	Cotton-wheat zone	Mixed zone	All zones	F-Test (F2, 1116)
Household head age (in years)	51 (13)	49 (13)	49 (12)	50 (13)	2.979*
Household head level of education (in years)	5.3 (1.3)	5.4 (1.5)	5.4 (1.3)	5.4 (1.4)	0.777
Household head farming experience (in years)	23 (13)	20 (12)	19 (12)	21 (12)	5.755*
Household size (number)	7.9 (3.5)	7.5 (3.9)	7.5 (3.6)	7.6 (3.7)	1.629

Note: Figures in parentheses are standard deviations

* Indicates significant at least 10 percent level of significance

¹ In Pakistan, farm sizes are commonly described as: marginal (less than 5 acres); small (5-12.5 acres); medium (12.5-25 acres); and large (more than 25 acres).

Figure 1: Share of Farmers by Farm Size and Agro-climatic Zone (%)



Note: chi-square = 3.34, p-value = 0.765

Table 2: Top Varieties - Distribution of Farmers, Years Grown, Wheat Area, Production, and Yield per Acre by Wheat Variety

	Proportion of farmers (%) ^a	Mean years variety grown	Proportion of wheat area (%) ^b	Proportion of wheat harvest (%) ^b	Average yield (kg/acres) (std. dev)
Seher-06	66.8	2.7	54.5	54.4	1,540 (343)
Inqilab-91	20.2	5.4	12.4	10.7	1,326 (337)
Watan-93	10.8	6.0	6.5	6.8	1,705 (1889)
Bhakkar-02	11.4	3.4	6.6	6.2	1,450 (352)
Faisalabad-08	6.2	1.8	5.4	6.0	1,637 (348)
A.S-2002	5.7	2.7	4.9	5.3	1,531 (318)
Shafaq-06	5.5	2.5	3.5	3.9	1,659 (380)
Lasani-08	4.5	1.9	2.9	3.4	1,649 (495)
Other varieties	5.4	2.8	3.3	3.3	1,598 (396)
All varieties		3.3	100	100	1,529 (637)

Note: ^a: some farmers were growing multiple varieties; the row total of proportions of farmer was calculated from total farmers in respective zone. The sum of these rows will not be equal to 100.

^b, ^c: The proportions of wheat area and wheat harvested are calculated as: $a_i = (\sum A_i / A) * 100$, where a_i is the proportion of wheat area (harvested quantity) under variety i , A_i is the total wheat area (harvested quantity) under variety i , and A is the total wheat area.

was grown across 43 percent of the wheat area in Punjab (Government of Punjab 2011). Seher-06 replaced the second most popular variety, Inqilab-91, within a few years of its release in 2007/08. Prior to the release of Seher-06, Inqilab-91 was grown for 13 years on over 70 percent of the wheat area of Punjab and on nearly half of Punjab in 2007/08 (Government of Punjab 2011). Most growers of Seher-06 adopted the variety three years prior to the survey, and the average number of years for growing a variety across agro-climatic zones and varieties is about three years.

Regardless of variety, large farmers have a significantly higher yield per acre than small and marginal farmers. Despite representing a small share (11 percent) of the total number of farmers, large farmers contributed more than half of total sales.

C. Traits

As part of the survey, farmers were asked to rank the importance of various traits of wheat varieties (1 being unimportant and 5 very important) and to rank the performance of the varieties they grow (1 being very poor and 5 very good). As Seher-06 and Inqilab-91 combined are grown by 87 percent of the sampled farmers, the results of the rankings are given for these two varieties in Table 3. The traits that were reported by farmers to be most important were grain yield, grain size, taste of roti², panicle length, price, roti color, and nutritional value. It was reported that Seher-06 has better production traits, while Inqilab-91 has better consumption traits. The results for trait rankings were not statistically different across agro-ecological zones.

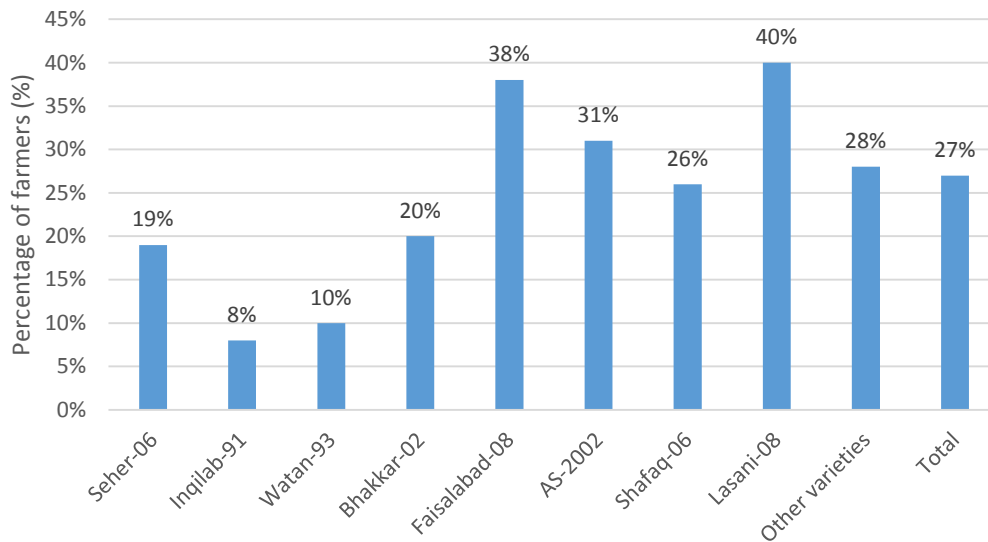
Wheat farmers face the challenges of wheat rust³, lodging⁴, and pests when cultivating some of the other popular varieties. The extent of these challenges differs

Table 3: Importance of Traits and Performance of Top Two Wheat Varieties

Traits	Seher-06		Inqilab-91	
	Proportion of farmers who perceive traits as important or very important (%)	Proportion of farmers reporting performance of their variety as well or very well (%)	Proportion of farmers who perceive traits as important or very important (%)	Proportion of farmers reporting performance of their variety as well or very well (%)
Days to maturity	62.2	45.8	69.9	45.8
Grain yield	99.7	76.3	100.0	50.9
Grain size	93.9	78.1	92.3	53.6
Panicle length (Bali)	87.2	71.8	81.0	51.8
Dry fodder yield	76.6	66.5	69.0	49.4
Resistance to pests	74.8	64.8	70.2	66.1
Resistance to rust	71.0	61.6	70.2	61.9
Resistance to lodging	79.5	51.1	78.6	60.7
Water requirement	66.6	21.4	72.6	20.8
Chemical fertilizer requirement	72.9	16.2	75.0	19.6
Less labor required	41.8	13.9	51.8	21.4
Price it fetches	92.0	61.8	89.3	60.1
Reliability of buyers/demand	85.2	64.1	80.4	65.5
Roti taste	93.5	68.2	93.5	91.7
Roti color	85.6	68.0	78.0	84.5
Roti overnight/long time keeping	70.9	36.1	65.5	51.8
Nutritional value	83.5	54.3	90.5	75.0

² Roti, or chapatti, is an unleavened, wheat flatbread commonly consumed as a staple in India and Pakistan

Figure 2: Newly Purchased Seed Use by Farmers in Rabi 2010/11, by Variety (%)



across varieties. Across the agro-climatic zones, farmers reported the highest incidence of wheat rust, lodging, and pests for Watan-93 (24 percent), Seher-06 (40 percent), and Bhakkar-02 (12 percent), respectively.

The color of roti made from variety was indicated as an important trait by farmers. The majority reported that roti made from Seher-06, Watan-93, and Bhakkar-02 is light in color, while roti made from Inqilab-91, Faisalabad-08, AS-2002, Shafaq-06, and Lasani-08 is medium in color. Very few farmers reported the production of dark-colored roti from any of the eight featured varieties.

Yield per acre is observed to be highest for Watan-93 (1,707 kg/acre), followed by Shafaq-06 (1,659 kg/acre), Lasani-08 (1,649 kg/acre), and Faisalabad-08 (1,637 kg/acre).

The data indicate that almost all varieties grown are late maturing, with the days of maturity falling in the range of 163 to 174 days.

Marketing traits are not reported to be as important as consumption and production traits, despite a majority of farmers selling most of their output. This might be because the wheat grain prices are determined by the government and do not differ significantly by variety.

D. Information Services

When deciding which variety to grow or what techniques to use when growing a new variety, the majority of farmers seek advice from informal sources. On average, friends, relatives, and landlords are consulted much more frequently than extension officers or media. However, those with large farms use private and public extension services as their primary sources of information and advice.

Media is a major source of general information about news, politics, sports, entertainment, and culture. Media, however, does not seem to be an important source for agricultural information.

E. Sources of Planting Material

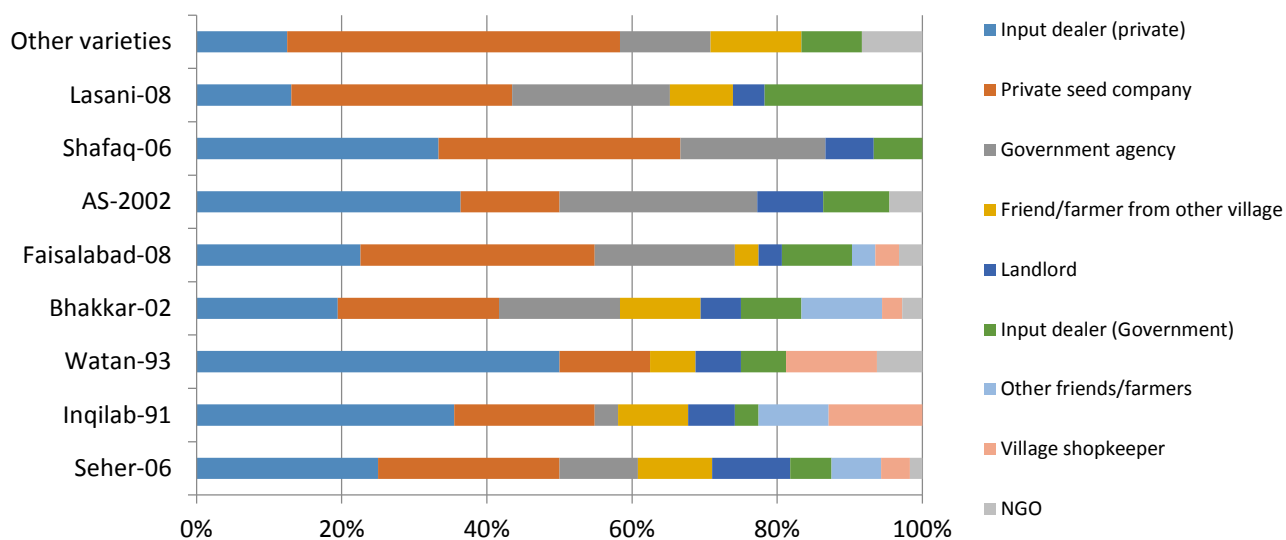
Of the sampled farmers, 74 percent used seed that they had saved from the previous season for planting. Very few farmers treated their seeds before planting, and the majority sowed using the broadcast method⁵. Twenty-seven percent of farmers indicated that they purchased seed in the preceding Rabi season. The proportion of wheat growers who purchased seed just before or during the Rabi 2010/11 season is presented by variety in Figure 2. Farmers either purchased seed to replace a store contaminated by weeds or to try a new variety hoping that it would perform better. As expected, very few farmers bought seeds of older varieties (Inqilab-91 and Watan-93).

³ Wheat rust is a fungal infection that attacks wheat leaves and causes severe yield losses.

⁴ Lodging is the bending of stems near ground level. High nitrogen fertilizer and water inputs can cause lodging, which results in uneven maturation of the crop, high moisture content in the grain, decreased grain quality due to shriveling, and increased harvesting costs (Ottman 2011).

⁵ Broadcast seeding is scattering seed by hand or mechanically. It is not precise and results in uneven distribution and possibly incorrect seed depth.

Figure 3: Major Sources of Wheat Seed - Percentage of Farmers Citing (%), by Variety



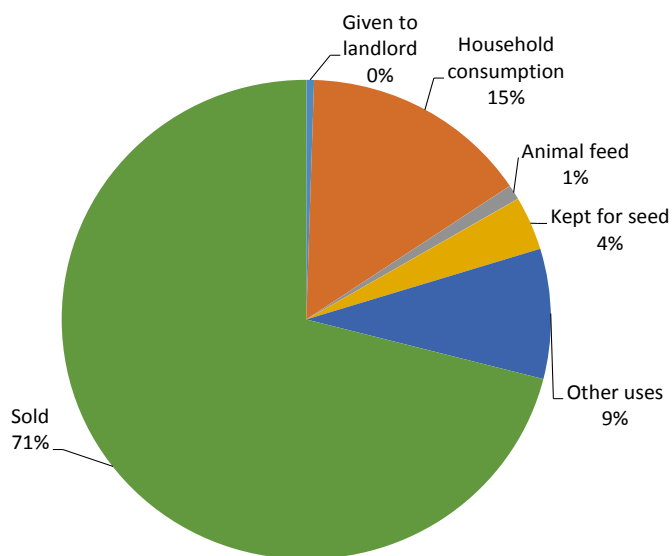
Seeds in Pakistan are distributed through the public and private sectors as well as informal channels. In the public sector, seed is distributed through provincial seed dealers. In the private sector, seed is distributed by sale points and agrochemical shops of registered national and international companies. Informal channels include other farmers, commission agents, private input dealers, and shopkeepers. The seed distributor varies according to which type of seed is being purchased, as shown in Figure 3, and also varies by agro-climatic zone and farm size. Most farmers buy their seed in a nearby urban area (41 percent) or within their own village (33 percent).

F. Output Use

About 21 percent of the output of Inqilab-91 is kept for home consumption compared with 15 percent of Seher-06. Most farmers (82 percent) sell the wheat that they produce, and generally 64 percent of sales occur on farm or at the farmer's home; however, place of sale differs significantly by agro-climatic zone and also by farmer type/farm size.

The percentage of production consumed at home decreases as farm sizes increases; marginal farmers keep 42 percent compared with large farmers only keeping 6 percent. The reverse is seen for sale of production with large farmers selling 82 percent of production verses 41 percent of marginal farmers. Generally, a small proportion of production is kept for planting in the next season. The proportion of wheat output typically saved for seed ranges from 3 percent for large farmers to 4 percent for marginal farmers. Marginal and small farmers kept a larger proportion for other uses (e.g., as gifts or to repay a loan) as compared with medium and large farmers. Figure 4 shows the output uses of all farmers.

Figure 4: Wheat Output Use (all farmers)



G. Labor

According to farmers' reports, the household head and the household head's son perform the majority of wheat farming activities. Other family members or hired casual labor are involved in some of the more labor-intensive activities like harvesting, threshing, storing, and bringing the produce from farm to home. Harvesting, threshing, storing, and weeding are the main activities for which casual labor is hired to supplement family labor.

H. Consumption, Storage, and Revenue

Most farmers (60 percent) consume only the wheat that they grow themselves. This implies that adoption of high-zinc wheat could have significant impact on the health outcomes of these households. Nearly 27 percent reported having bought wheat grain, 11 percent bought wheat flour, and 2 percent bought both grain and flour. Wheat planting in Pakistan starts after November 15, and harvesting is completed by the end of May. As evidenced in Figure 5, which shows wheat purchases from 2010–2011, wheat stocked in April or May usually lasts households in the irrigated area of Punjab about six months, then they must buy grain or flour for household consumption. Therefore, during those months, households that have adopted high-zinc wheat may not be consuming high-zinc wheat if it is not available in the market.

I. Food Frequency

Wheat, edible oil, spices, sweeteners, milk and milk products, and beverages are the foods or products consumed every day by almost all households. Rice is consumed frequently, although wheat is the much preferred staple. Pulses (such as lentils) are more commonly consumed than meat, fish, poultry, or eggs. Pulses and tubers are more frequently consumed than vegetables.

In Pakistan, wheat is consumed in several ways. Roti/paratha/puri is usually eaten with breakfast, lunch, or dinner; bread and daliya (crushed wheat kernel) are usually eaten for breakfast or when a person is ill; samosa, biscuits, and cake are eaten as a snack; halwa and sewyan are sweet

and usually eaten as dessert or snack at different festive occasions. Roti is the most commonly consumed wheat product and was eaten by almost all respondents in the seven days before the survey. All of the farmers converted their wheat into wheat flour, and most did so at a mill or grinder in their village.

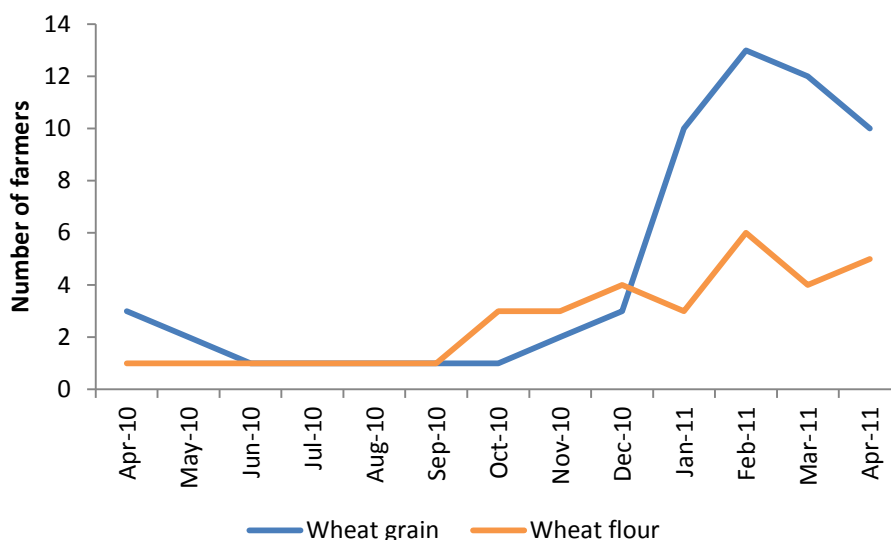
IV. CONCLUSIONS

HarvestPlus and its partners are using conventional breeding methods to develop wheat varieties that are enriched with zinc; these varieties are planned to be introduced into the market in 2015. To facilitate delivery and marketing of zinc-rich wheat, and to later monitor adoption trends, HarvestPlus and its partners conducted a varietal adoption survey in Punjab province in 2011.

The survey revealed that Seher-06 was the most popular variety, planted by 67 percent of farmers. Other common varieties were Inqilab-91, Watan-93, Bhakhar-02, and Faisalabad-08. Yield per acre was observed to be highest (1,707 kg/acre) for Watan-93, followed by Shafaq-06 (1,659 kg /acre), Lasani-08 (1,649 kg/acre), and Faisalabad-08 (1,637 kg/acre). Large-scale farmers obtained higher per acre yields than farmers in other farm size categories.

Most wheat output was sold. Farmers kept a higher proportion of Inqilab-91, Watan-93, and Bhakkar-02 for home consumption and sold a larger proportion of Faisalabad-08, Lasani-08, AS-2002, Shafaq-06, and Seher-06. Generally it appears that varieties that perform well in terms of production traits (yield, size of grain, and

Figure 5: Wheat Purchases (Grain and Flour) by Month during Rabi 2010/11



panicle length) are sold, while varieties that perform well in terms of consumption traits (taste and color of roti) are kept for home consumption. Comparing across farm size, the results indicate that marginal farmers keep a larger proportion of production for home consumption (42 percent). Despite this fact, they are able to sell 41 percent of their total production.

The majority of farmers obtained agricultural information and advice from informal sources, such as friends, relatives, and large landlords in the village. The share of formal sources (extension officers and media) was low.

The majority of farmers acquired seed either from the previous harvest or just before the start of sowing season; more than two-thirds of farmers replaced or changed their wheat seed every two to four years. The distribution of wheat sales was highly skewed, as was land distribution. More than half of the total amount of wheat sold was produced by 11 percent of farmers. Only 23 percent of farmers purchased seed. Input dealers appeared to be the major source of purchased seed for most varieties. Most purchased seed was sourced from the city or the farmer's village. Farmers indicated grain yield, grain size, and the taste of roti to be the most important traits.

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