

# Increasing Food Diversity and Nutritional Yield: Evaluating Diverse Cropping Systems

A Field Study in Chapainawabganj  
District in Bangladesh

Research note 43

October 2024

## ABOUT THIS NOTE

Over the past two decades, Bangladesh has made significant strides in food production, particularly in rice, the country's primary crop (ADB, 2023). However, many people still lack access to a nutritious and diverse diet. Diets remain imbalanced, with rice contributing around 70% of total energy intake (BBS, 2010). The increased production of high-yielding cereals like rice, maize, and wheat has replaced more nutrient-rich cereals like millet, oats, and sorghum. New approaches are needed to produce nutrient-rich foods while using land efficiently. A farmers' participatory research trial was conducted in Chapainawabganj, and a research brief summarizes the results of the nutrition yield of diverse, intensified cropping systems compared to farmers' common practices from 2022–23 in Chapainawabganj, Bangladesh.

## KEY STUDY FINDINGS

1. The study found that the Rice–Maize+red amaranth–Sorghum (fodder) cropping system significantly outperformed the Rice–Wheat–Fallow system in nutritional yield. It showed increases of 122% in carbohydrates, 167% in protein, 282% in fat, 185% in zinc, 176% in iron, and substantial gains in vitamin A and C yields.
2. The superior performance of the Rice–Maize+red amaranth–Sorghum (fodder) system can be attributed to several factors. Maize, with its high grain yield, significantly boosted carbohydrate and protein levels, while intercropping with leafy vegetables like red amaranth enriched the system with essential vitamins and minerals.
3. These findings highlight the potential of intensifying and diversifying traditional rice-based cropping systems to enhance both food security and nutritional outcomes. For instance, incorporating biofortified rice varieties enriched with zinc and iron provides a sustainable pathway to improving dietary diversity and ensuring a more balanced diet. This is especially crucial for smallholder farmers and vulnerable groups, such as children and pregnant women, who are at a higher risk of malnutrition.

## BACKGROUND

Chapainawabganj District, located in the Barind Tract of northwestern Bangladesh, is predominantly characterized by rice–rice cropping systems. Despite significant progress in food production, particularly in rice, much of the population in this region still lacks access to a balanced and diverse diet (Iqbal et al., 2024). Malnutrition remains a critical concern, with over one-third of children experiencing stunted growth. Diets are heavily dependent on rice, which contributes approximately 70% of total energy intake (HIES, 2010). Furthermore, 40% of the population derives less than 10% of their total calories from protein, and 53% consume less than 15% from fat, exacerbating issues such as stunting, wasting, and underweight conditions (BNNC, 2021).

Micronutrient deficiencies, including inadequate intake of vitamin A, calcium, iron, zinc, and folic acid, are prevalent in the region. The dietary diversity score for 50% of households is below six, indicating a serious risk of malnutrition (BNNC, 2021). Vulnerable groups, such as children, pregnant women, and adolescents, are especially at risk.

Recent advances in biofortified rice varieties, such as BINA Dhan 20 (Aman) and Bango Bandhu Dhan 100, offer potential solutions by contributing to nutritional security, particularly for zinc (Zn) and iron (Fe). For example, BINA Dhan 20 can provide sufficient Zn and Fe for 27 and 26 adults per hectare per year, respectively, while non-biofortified rice provides only 18 and 10 adults per hectare per year for Zn and Fe, respectively.

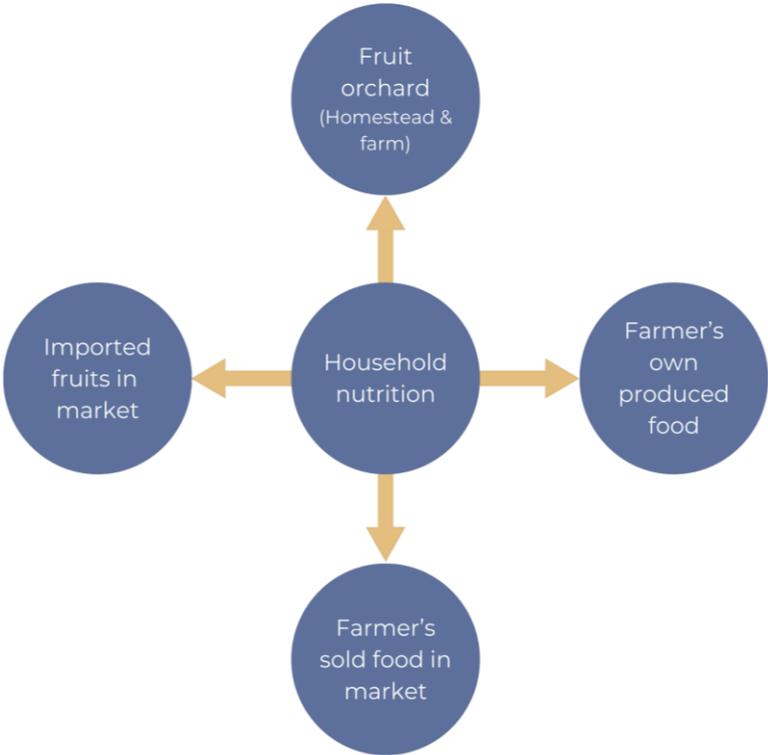
However, Bangladesh’s agricultural policies have traditionally focused on single-crop production, with limited attention to integrated, multisectoral approaches that consider both farm productivity and nutritional outcomes. There is a pressing need to diversify existing rice-based systems by incorporating nutrient-rich crops, such as vegetables (e.g., carrots, summer tomatoes), to improve dietary diversity and combat malnutrition, especially for vulnerable populations in Chapainawabganj.

Sustainable intensification and diversification of these systems could increase the availability of essential nutrients while ensuring that farming practices remain within environmental limits. By strengthening linkages between food production, household nutrition, and market systems, farming communities in Chapainawabganj can generate profits and access nutritious food, helping reduce inefficiencies in value chains and lower consumer prices for healthier products.

The study calculated the nutritional yield of macro- and micronutrients from different cropping systems to evaluate their contribution to meeting the Dietary Recommended Intake (DRI). The nutritional yield represents the number of adults whose yearly recommended intake of a specific nutrient can be met by one hectare of land (DeFries et al., 2015). In Chapainawabganj, where farmers both consume their produce and sell excess food in local markets, adopting diversified cropping systems, including biofortified crops and vegetables, can play a crucial role in improving diets and addressing malnutrition, particularly for pregnant women, children, and adolescents.

**Table 1:** Functions of carbohydrate, protein, fat, zinc, iron, vitamin c, and vitamin A (MOA, 2015)

Nutrient	Functions
<b>Carbohydrate</b>	The main source of energy in the body to function the metabolic process
<b>Protein</b>	Maintenances growth, development, and repair of the body.
<b>Fat</b>	Produce energy, a source of essential fatty acids, that the body cannot produce on its own, and helps the body absorb fat-soluble vitamins such as A, D, E, and K.
<b>Zinc</b>	Growth and maintenance of immune function for both the prevention of and recovery from infectious diseases.
<b>Iron</b>	Important for hemoglobin production in blood, and it helps to carry oxygen and transport it throughout the body. Children, adolescents, and pregnant women suffer more from anemia due to a lack of iron-rich food.
<b>Vitamin C</b>	Essential for skin health, immune function, iron absorption, and overall tissue repair and protection.
<b>Vitamin A</b>	Essential for vision, immune function, skin health, cell growth, reproduction, etc.



**Figure 1:** Food channels among farmers' households in Chapainawabganj

## OBJECTIVES

The research aims to evaluate the nutritional yields of different cropping system options and compare them with traditional cropping practices in the region. It also seeks to enhance farmers' dietary habits and nutritional intake while conserving resources and improving ecological services. A participatory research approach was used to select various cropping systems, involving local stakeholders to ensure relevance. Key objectives include:

Assess the nutritional yields of alternative cropping systems and compare them with farmers' common practices to identify the most beneficial options.

## DATA AND METHODS

### SITE DESCRIPTION

Researcher-managed and farmer-participatory field trials were conducted across rainfed and partially irrigated environments in the Barind Tract, Chapainawabganj district, in northwest Bangladesh. The trials took place in 20 farmers' fields in each village (Bashbaria and Sobdolpur). The trials spanned three cropping seasons: the 2022-23 winter 'rabi,' pre-monsoon 2023 'kharif 1,' and monsoon 2023 'kharif 2.' The Barind Tract is known for its challenging agroecological conditions, including limited rainfall, high temperatures, and declining groundwater levels.

## TREATMENT SELECTION

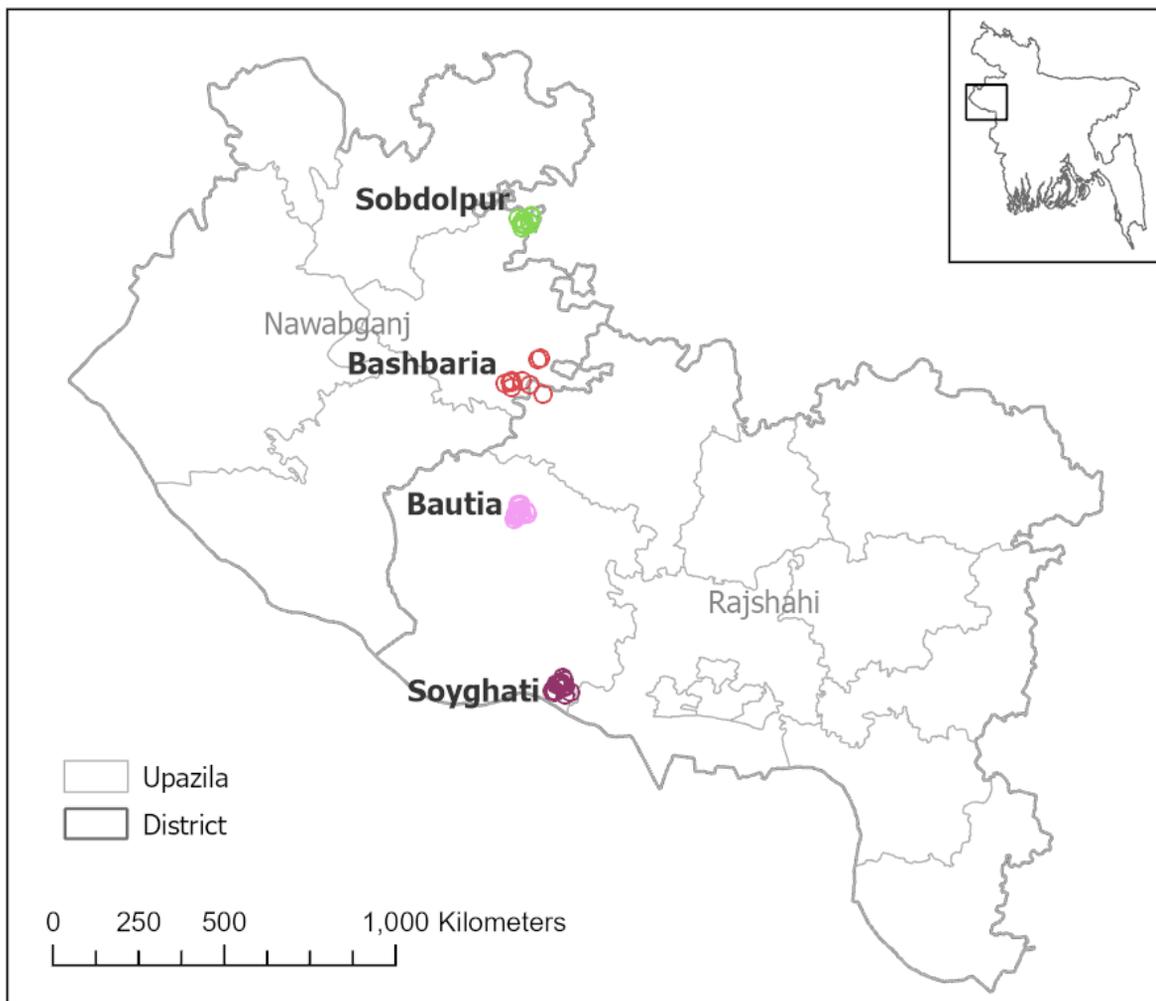
The cropping patterns for the study were chosen through a participatory process involving 50 farm households in each village. Farmers ranked various cropping options, and the three highest-scoring patterns were selected for the trials. These patterns were then compared against the common cropping pattern used in the region. This method ensured that the chosen cropping systems reflected farmers' preferences, increasing the likelihood of adoption if the trials proved successful (Table 1).

## EXPERIMENTAL DESIGN

The on-farm research trials follow a randomized complete block design (RCBD), with 20 farmer households as the replications within each village. In four villages, three diversified cropping patterns and a farmers' practice are being compared. The plot size is 150-300 m<sup>2</sup> per treatment.

## CROP MANAGEMENT

The planting of the Kharif 1 crops (sweet corn, sorghum, and cowpea) ranged from 1 to 15 March 2023. Kharif 2 rice was transplanted from 1 to 20 August 2023, using 25–30-day-old seedlings, and the rabi crops (maize, mustard) were planted from 10 to 20 November 2023. In all three seasons, the crops were fertilized according to the Bangladesh Fertilizer Recommendation Guidebook (FRG, 2018). Weed control, pest management, irrigation, and other practices were carried out following standard agronomic procedures.



**Figure 2:** Small circles indicate the farmers' participatory trial fields at Bashbaria and Sobdolpur villages in Chapainawabganj district

**Table 2:** Description of cropping patterns

Treatment code	<i>Kharif-2</i>	<i>Rabi</i>	<i>Kharif-1</i>
R-L-Sc	Rice	Lentil	Sweet corn
R-M+Ra-S	Rice	Maize+Red amaranth	Sole sorghum (Fodder)
R-Cp-S+C	Rice	Chickpea	Sorghum+Cowpea (fodder)
R-W-F	Rice	Wheat	Fallow

**Note:** R-L-Sc: Rice-Lentil-Sweet Corn; R-M+Ra-S: Rice-Maize intercrop with Red Amaranth-Sole Sorghum (fodder), R-Cp-S+C: Rice-Chickpea-Sorghum intercrop with Cow Pea (Fodder), R-Wheat-F: Rice-Wheat-Fallow

## DETERMINATION OF NUTRITION YIELD

First, to determine the nutritional yield, it is important to understand the Daily Dietary Recommendation (DRI). The DRI of a particular nutrient refers to the nutrient requirement of a healthy individual in a specific stage of life or gender group (Table 3).

The nutritional yield of a specific nutrient refers to the number of adults who can meet 100% of the DRI for that nutrient for an entire year from the production of one hectare of land (Equ-1) (DeFries et al., 2015).

## STATISTICAL ANALYSIS

The data were analyzed using a randomized complete block design (RCBD), with the 20 farmer fields in each location serving as replications (random effect). Fixed effects included village, treatment (cropping pattern), and their interaction. The statistical analyses were performed using JMP14 (SAS Institute Inc., San Francisco). Means of the inputs and outputs across the cropping systems were compared using Tukey's Honest Significant Difference (HSD) test at a significance level of  $P \leq 0.05$  to determine whether the differences in yields and economic returns were statistically significant (Gomez, 1984).

$$NY_{ij} \text{ (adult/ha per year)} = \frac{Y_j \text{ (t/ha)} \times 10^6 \times Nc_{ij} \text{ (\%)}}{DRI_i \text{ (g/adult/day)} \times 365} \dots \dots \dots (1)$$

Where, NY = nutrition yield; Nc = Nutrient content; DRI = daily dietary reference intake; Y= crop yield; The subscripts "i" and "j" refer to the nutrient of interest and crop, respectively. Note that the source of nutrient content values is the Food Composition Table for Bangladesh, published in 2013.



**Above:** Chickpeas on right, maize in front, and wheat on the left side, trial plot, rabi, 2022-23 in Bashbaria, Chapainawabganj, Bangladesh; photo: Juel Rana

**Table 3:** DRI of carbohydrate, protein, fat, zinc, iron, vitamin C, and vitamin A (Macro nutrients from DeFries et al., 2015, minerals and vitamins from Mahajabin et. al., 2021)

DRI (g/adults/day)						
Carbohydrate	Protein	Fat	Zinc	Iron	Vitamin C	Vitamin A
431.5	56	96	0.012	0.012	0.08	0.007

**Note:** Values are used to calculate nutrition yield

**Table 4:** Nutrient content of component crops of cropping system options (Shaheen et al., 2013, DeFries et al., 2016)

Crop	Nutrient content (g 100 <sup>-1</sup> g)						
	Carbohyd rate	Protein	Fat	Zinc	Iron	Vit-C	Vit-A
Rice (BF)	76.8	6.5		0.00265	0.002		-
Rice(NBF)	76.8	6.5	0.4	0.00132	0.0007		-
Wheat	62	11.2	2.9	0.00279	0.0049		-
Maize	64.7	9.9	3.4	0.00327	0.0029		0.000011
Sweet corn	28.7	3.5	1.4	0.0008	0.0007	0.0059	0.000004
Lentil	43.2	27.7	0.8	0.00389	0.0051	-	0.000003
Chickpea	44.8	20.4	6	0.00268	0.0088	0.004	0.000003
Red amaranth	0.5	4.5	0.3	0.00096	0.006	0.042	0.000793

**Note:** Values are used to calculate nutrition yield

**Table 5:** Yield of component crops of cropping system options from field trials 2022-23, Chapainawabganj

Village	Cropping system	Crop yield (t ha <sup>-1</sup> )		
		Kharif 2	Rabi*	Kharif 1
Bashbaria	R-L-Sc	3.55	1.83	4.15
	R-M+Ra-S	3.56	13.76 (4.6)	
	R-Cp-S+C	3.55	1.91	
	R-W-F	3.55	4.07	
Sobdolpur	R-L-Sc	3.86	2.00	4.42
	R-M+Ra-S	3.87	13.73 (5.4)	
	R-Cp-S+C	3.85	1.85	
	R-W-F	3.84	3.88	

**Note:** R-L-Sc: Rice-Lentil-Sweet corn; R-M+Ra-S: Rice-Maize intercrop with Red amaranth-Sole Sorghum (fodder), R-Cp-S+C: Rice-Chickpea-Sorghum intercrop with cowpea (fodder), R-Wheat-F: Rice-Wheat-Fallow  
\*The value in parenthesis is the fresh yield of red amaranth intercropping with maize in rabi season [Values are used to calculate nutrition yield]

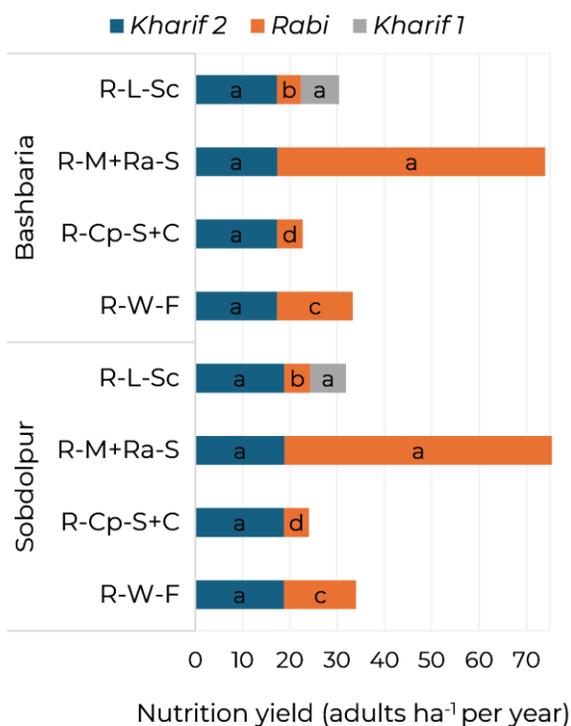
## STUDY FINDINGS

### NUTRITION YIELD OF CARBOHYDRATES

Carbohydrates are the primary source of energy and predominantly come from cereals (MOA, 2015). The field study showed that the nutrition yield (NY) of carbohydrates varied significantly across different cropping system options (T), but there were no significant differences between the villages (L) or the interaction between location and treatment (L×T) (Table 3). The highest NY of carbohydrates (75 adults ha<sup>-1</sup> per year) was observed in the R-M + Ra-S cropping system in both villages, while the lowest NY of carbohydrates (32 adults ha<sup>-1</sup> per year) was found in the R-L-Sc system. This higher NY is attributed to the significantly greater grain production of maize during the rabi season at both locations. In terms of the nutrition yield of carbohydrates, the cropping systems ranked as follows: R-M + Ra-S > R-W-F > R-L-Sc > R-Cp-S+C. A similar trend was observed in the component crops of the systems during the rabi season. During Kharif 2, all plots were planted with rice (BINA dhan 20), and no significant differences were observed between treatments (Figure 3 and Table 6).

In the R-M+Ra-S system, maize contributed significantly to the NY of carbohydrates. However, maize is not consumed as human food in this area; it is primarily used for poultry and dairy feed. During the kharif season, only sweet corn was included in the NY analysis, while sorghum and cowpea were excluded as they are grown here as fodder crops. In the R-W-F system, wheat serves as a valuable source of carbohydrates. Incorporating fodder crops, minor cereals, leafy vegetables,

or black gram into Kharif 1 could potentially enhance the sustainability of these cropping systems in terms of nutritional yield. The findings suggest that diversified cropping systems, particularly those integrating cereals like maize and wheat, can significantly improve the NY of carbohydrates during the rabi season. Adapting cropping systems to include nutritionally beneficial crops across different seasons could enhance both food security and nutritional outcomes, promoting more resilient and sustainable agricultural practices.



**Figure 3:** Nutrition yield of carbohydrate by component crops and cropping systems in Bashbaria and Sobdolpur villages, Chapainawabganj, 2022-23

**Note:** R-L-Sc: Rice-Lentil-Sweet Corn; R-M+Ra-S: Rice-Maize intercrop with red amaranth-Sole Sorghum (fodder), R-Cp-S+C: Rice-Chickpea-Sorghum intercrop with cowpea (Fodder), R-WF: Rice-Wheat-Fallow. Means followed by the same lower-case letters in the same color bars are not significantly different (at p<0.05) according to Tukey's HSD test.

## NUTRITION YIELD OF PROTEIN

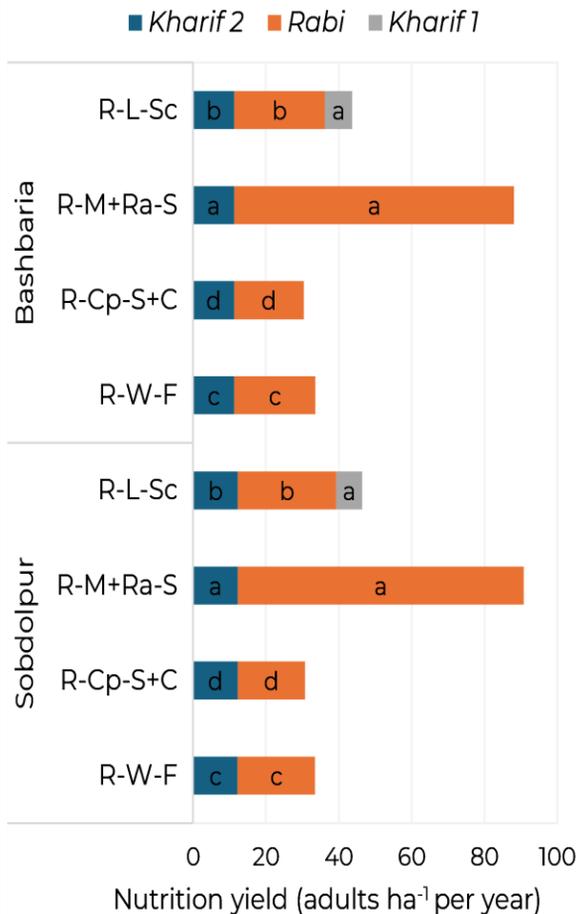
Protein is a vital macronutrient for human health, supporting growth, development, and the maintenance and repair of body tissues. While proteins can be obtained from both animal products (meat, fish, poultry, eggs, and dairy) and plant-based foods (grains, legumes, nuts, and beans), certain amino acids—nine of which are essential—must be acquired through the diet (MOA, 2015). To meet these needs, it is crucial to incorporate diverse crops into cropping systems that can provide sufficient protein.

In the study, the highest nutrition yield (NY) of protein (89 adults ha<sup>-1</sup> per year) was observed in the R-M + Ra-S cropping system, primarily due to the significantly higher grain yield of maize during the rabi season at both locations. The ranking of cropping systems based on protein yield was as follows: R-M + Ra-S > R-L-Sc > R-W-F > R-Cp-S+C (Figure 4 and Table 6). Although the R-M + Ra-S system had the highest protein yield, it is important to note that maize, the major contributor, is primarily used as animal fodder rather than for direct human consumption.

In contrast, the R-L-Sc system, which includes lentils—a rich source of plant-based protein—provides a more sustainable and practical source of dietary protein for human consumption. Lentils, as a pulse crop, are an excellent source of essential amino acids, making this system better aligned with human dietary needs.

In conclusion, while the R-M + Ra-S cropping system provides the highest protein yield, its primary use as fodder limits its direct nutritional benefits to humans. On the other hand, the R-L-

Sc system, with its pulse crops like lentils, offers a more balanced and sustainable source of plant-based protein. This underscores the importance of selecting crops not only based on yield but also on their nutritional value and consumption patterns, reinforcing the need for crop diversification to optimize food security and nutrition.



**Figure 4:** Nutrition yield of protein by component crops and cropping systems in Bashbaria and Sobdolpur villages, Chapainawabganj, 2022-23

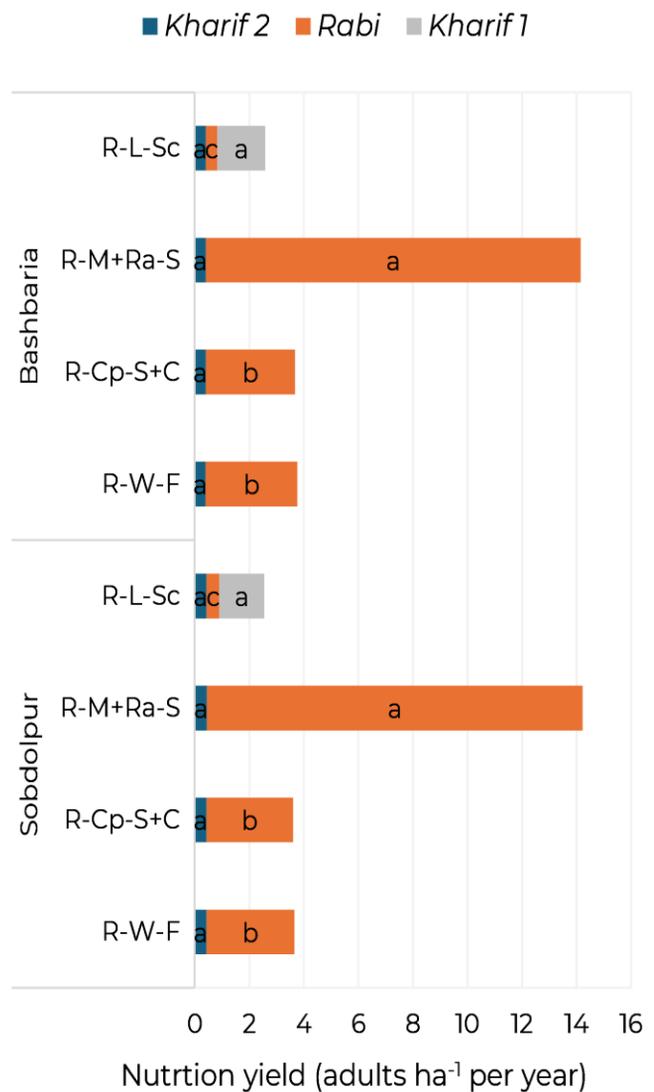
**Note:** R-L-Sc: Rice-Lentil-Sweet Corn; R-M+Ra-S: Rice-Maize intercrop with red amaranth-Sole Sorghum (fodder), R-Cp-S+C: Rice-Chickpea-Sorghum intercrop with cowpea (Fodder), R-WF: Rice-Wheat-Fallow.

## NUTRITION YIELD OF FAT

Fat is an essential macronutrient that provides fatty acids the body cannot produce on its own. It also plays a critical role in the absorption of fat-soluble vitamins, such as A, D, and E, which can only be utilized by the body in the presence of fats (MOA, 2015). Therefore, incorporating oilseed crops into cropping systems is crucial to meeting dietary fat requirements.

In the study, the highest NY of fat (14 adults ha<sup>-1</sup> per year) was observed in the R-Cp-S+C cropping system, while the lowest NY of fat (3 adults ha<sup>-1</sup> per year) was recorded in the R-L-Sc system (Figure 5 and Table 6). The lower fat yield in the R-L-Sc system is attributed to the absence of oilseed crops in the rotation.

To improve fat yield in these systems, incorporating an oilseed crop instead of chickpea would make the system more efficient and sustainable by meeting the local demand for edible oil. This adaptation would not only enhance the nutritional profile of the cropping system but also contribute to the region's self-sufficiency in oil production, reducing reliance on external sources and promoting healthier dietary options.



**Figure 5:** Nutrition yield (adults ha<sup>-1</sup> per year) of fat by component crops and cropping systems in Bashbaria and Sobdolpur villages, Chapainawabganj 2022-23

**Note:** **R-L-Sc:** Rice-Lentil-Sweet Corn; **R-M+Ra-S:** Rice-Maize intercrop with red amaranth-Sole Sorghum (fodder), **R-Cp-S+C:** Rice-Chickpea-Sorghum intercrop with cowpea (Fodder), **R-WF:** Rice-Wheat-Fallow.

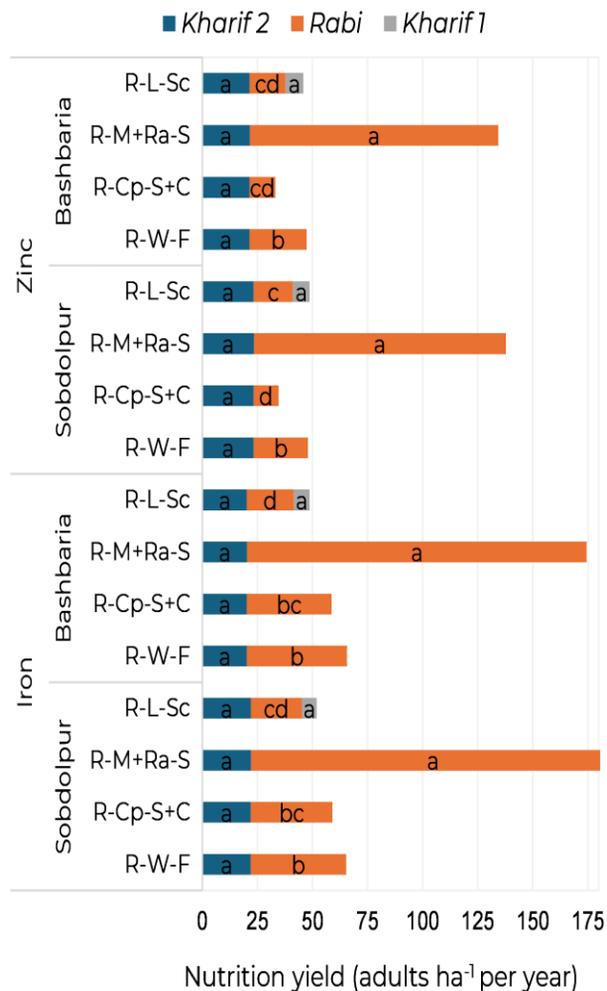
## NUTRITION YIELD OF MINERALS

Iron and zinc are essential minerals for human health, playing key roles in immune function, cognitive development, and overall well-being (MOA, 2015). The NY of iron and zinc varied significantly across different cropping system options (T), though no significant differences were observed between locations (L) or in the interaction between location and treatment (L×T) (Table 6). The highest NY of zinc (134–138 adults ha<sup>-1</sup> per year) and iron (174–181 adults ha<sup>-1</sup> per year) were observed in the R-M + Ra-S cropping system at both locations, primarily due to the significantly higher grain production of maize during the rabi season in these systems. In contrast, the lowest NY of zinc (34 adults ha<sup>-1</sup> per year) was recorded in the R-Cp-S+C system, while the lowest NY of iron (50 adults ha<sup>-1</sup> per year) was observed in the R-L-Sc system (Figure 6 and Table 6).

While the R-M + Ra-S system offers the highest yields of iron and zinc, its reliance on maize—primarily used as animal feed—limits its direct nutritional benefits to humans. For human consumption, the R-W-F system may present a more efficient and sustainable option, provided that a suitable crop is included to enhance mineral yields while considering local weather conditions. By diversifying the crop selection, this system could potentially provide greater nutritional value for human diets, addressing mineral deficiencies and the broader need for sustainable agricultural practices.

In conclusion, while the R-M + Ra-S system excels in mineral yields, its practical application for human nutrition is limited. The R-W-F system, with appropriate crop modifications,

could become a more effective and sustainable option for improving iron and zinc intake, better aligning with local dietary needs and environmental conditions.



**Figure 6:** Nutrition yield (adults ha<sup>-1</sup> per year) of iron and zinc by component crops and cropping systems in Bashbaria and Sobdolpur villages, Chapainawabganj 2022-23.

**Note:** R-L-Sc: Rice-Lentil-Sweet Corn; R-M+Ra-S: Rice-Maize intercrop with red amaranth-Sole Sorghum (fodder), R-Cp-S+C: Rice-Chickpea-Sorghum intercrop with cowpea (fodder), R-W-F: Rice-Wheat-Fallow. Means followed by the same lower-case letters in a column are not significantly different (at p<0.05) according to Tukey's HSD test.

**Table 6:** Nutrient yield assessed by cropping systems options for carbohydrate, protein, and fat in Bashbaria and Sobdolpur, Chapainawabganj, 2022-23

Source	Nutrition yield (adults ha <sup>-1</sup> per year)						
	Carbohydrate	Protein	Fat	Zinc	Iron	Vit-A	Vit-C
<b>Village (V)</b>							
Bashbaria	40a	49a	6a	65a	87a	75a	38a
Sobdolpur	41a	50a	6a	67a	91a	87a	43a
<b>Cropping system (T)</b>							
R-L-Sc	31c	45b	3c	47b	50c	1b	9b
R-M+Ra-S	75a	89a	14a	136a	181a	161a	72a
R-Cp-S+C	23d	31d	4b	34c	59bc	-	
R-W-F	34b	34c	4b	48b	66b	-	
<b>V × T</b>							
Bashbaria, R-L-Sc	30b	44b	3c	46b	49c	1b	9b
Bashbaria, R-M+Ra-S	74a	88a	14a	134a	174a	149a	66a
Bashbaria, R-Cp-S+C	23c	30c	4b	33c	59bc	-	
Bashbaria, R-W-F	33b	34c	4b	47b	66b	-	
Sobdolpur, R-L-Sc	32b	46b	3c	49b	52bc	1b	8b
Sobdolpur, R-M+Ra-S	75a	91a	14a	138a	187a	174a	78a
Sobdolpur, R-Cp-S+C	24c	31c	4b	35c	59bc	-	
Sobdolpur, R-W-F	34b	34c	4b	48b	65c	-	
<b>Sources of variation</b>							
	Value of Probability						
V	0.170	0.168	0.749	0.159	0.181	0.206	0.225
T	<.001	<.001	<.001	<.001	<.001	<.001	<.001
V × T	0.951	0.429	0.952	0.743	0.242	0.205	0.186

**Note:** R-L-Sc: Rice-Lentil-Sweet corn; R-M+RA-S: Rice-Maize intercrop with red amaranth-Sole sorghum (fodder), R-Cp-S+C: Rice-Cp-Sorghum intercrop with Cow Pea (fodder), R-W-F: Rice-Wheat-Fallow. Means followed by the same lower-case letters in a column are not significantly different (at p<0.05) according to Tukey's HSD test.



**Above:** Sorghum (as fodder) was grown only in the trial plot during Kharif 1, 2022, in Sobdolpur, Chapainawabganj, while the surrounding lands were left fallow; photo: Juel Rana

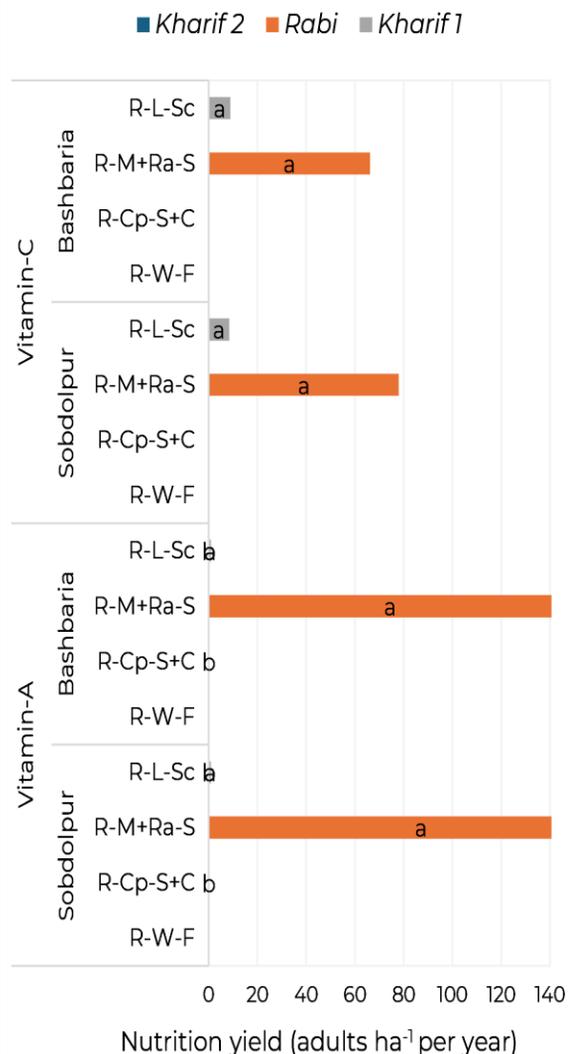
## NUTRITION YIELD OF VITAMINS

The study showed that the NY of vitamins A and C varied significantly across different cropping system options and between villages (Table 6). The highest NY of vitamin A (161 adults ha<sup>-1</sup> per year) and vitamin C (72 adults ha<sup>-1</sup> per year) were observed in the R-M + Ra-S cropping system. These high yields are attributed to the significantly higher grain production of maize and the intercrops grown during the rabi season at both locations. A similar trend was noted in other rabi crops within these systems. However, during Kharif 2, all plots were planted with rice (BINA dhan 20), which did not contribute to the vitamin yield in that season (Table 6 and Figure 7).

To enhance the vitamin yield of cropping systems, incorporating crops rich in vitamins—such as leafy vegetables, tomatoes, carrots, and cauliflower—could significantly boost their nutritional content. However, the success of these crops depends on local weather and soil conditions, which must be carefully considered before inclusion. Adding vitamin- and mineral-enriched crops could help meet the dietary requirements for essential nutrients.

In conclusion, while the R-M+Ra-S system excels in vitamin yield, there is room for improvement by diversifying the cropping systems with vegetables and other vitamin-rich crops. Such an approach would provide a more balanced nutritional outcome, making the systems more effective in addressing the micronutrient deficiencies prevalent in many regions. This strategy could not only improve

food security but also contribute to better overall health outcomes by ensuring a diet rich in essential vitamins and minerals.



**Figure 7:** Nutrition yields (adults ha<sup>-1</sup> per year) of vitamin C and vitamin A by component crops and cropping systems in Bautia and Soyghati villages, Chapainawabganj, 2022-23.

**Note:** R-L-Sc: Rice-Lentil-Sweet Corn; R-M+Ra-S: Rice-Maize intercrop with red amaranth-Sole Sorghum (fodder), R-Cp-S+C: Rice-Chickpea-Sorghum intercrop with cowpea (fodder), R-WF: Rice-Wheat-Fallow.

## CONCLUSIONS AND RECOMMENDATIONS

The results in the research brief were derived from the NY of macro- and micronutrients across different cropping system options. These cropping systems included: Rice-Lentil-Sweet Corn, Rice-Maize intercropped with Red Amaranth and Sole Sorghum (as fodder), Rice-Chickpea intercropped with Sorghum and Cowpea (as fodder), and Rice-Wheat-Fallow, which aimed to promote dietary diversity and healthier nutrition. The Rice-Wheat-Fallow system is considered the farmers' common practice, while the other three represent intensive and diversified alternative cropping systems. The experiment was conducted in 40 farmers' fields across two villages in the Rajshahi district of Bangladesh.

The study revealed that the NY of macro- and micronutrients in intensive and diversified alternative cropping systems was significantly higher than that of the common Rice-Wheat-Fallow cropping practice among farmers in Rajshahi. The Rice-Maize + Red Amaranth-Sorghum (fodder) system demonstrated the highest nutritional yield of carbohydrates, protein, fat, zinc, and iron compared to all other cropping systems. On average, it exhibited a 122% increase in carbohydrates, a 167% increase in protein, a 282% increase in fat, a 185% increase in zinc, and a 176% increase in iron compared to the Rice-Wheat-Fallow system. Additionally, there were significant increases in Vitamin A and Vitamin C in this system compared to other cropping systems. The superior performance of the Rice-Maize + Red Amaranth-Sorghum (fodder) system is attributed to the

high grain yield of maize and the intercropping with leafy vegetables like red amaranth, which contributed to increased vitamins and minerals. Although maize is not consumed as human food in this area, it is primarily used for poultry and dairy feed, with poultry serving as a key source of protein for the local population. These results suggest that intensifying and diversifying rice-based cropping systems, including biofortified rice varieties enriched with zinc and iron, can sustainably improve smallholder dietary diversity and balanced diets while reducing the risk of malnutrition, particularly for children and pregnant women. These findings are critical for millions of marginal farmers across Bangladesh.



**Above:** BINA dhan 20 (Biofortified) on the right, BRRI dhan 51 on the left side, trial plot, *kharif* 2, 2023 in Bashbaria, Chapainawabganj; photo: Juyel Rana

## REFERENCES

- ADB. (2023). *Bangladesh's agriculture, natural resources, and rural development sector assessment and strategy*. Asian Development Bank. Retrieved from: <https://doi.org/10.22617/TCS230050>
- Bangladesh Bureau of Statistics. (2010). *Report of the Household Income and Expenditure Survey (HEIS)*. Statistics Division, Ministry of Planning, Government of Bangladesh.
- Bangladesh National Nutrition Council. (2021). *Assessment of the key bottlenecks for the coverage of nutrition-sensitive interventions and the underlying causes*. Ministry of Health and Family Welfare, Government of the People's Republic of Bangladesh, 9–16.
- Cheesman, S., Islam, M. S., Kurishi, A., Hossain, M. S., Fedous, M. Z., Huda, M. S., Gathala, M. K., & Krupnik, T. J. (2022). *TAFSSA on-farm research trials Bangladesh: Protocol for field implementation*. International Center for Maize and Wheat Improvement (CIMMYT).
- DeFries, R., Fanzo, J., Remans, R., Palm, C., Wood, S., & Anderman, T. L. (2015). Metrics for land-scarce agriculture. *Science*, 349(6245), 238–240. Retrieved from: <https://doi.org/10.1126/science.aaa5766>
- Fahim, S. M., Hossain, M. S., Sen, S., Das, S., Hossain, M., Ahmed, T., Mustafizur Rahman, S. M., Rahman, M. K., & Alam, S. (2021). Nutrition and food security in Bangladesh: Achievements, challenges, and impact of the COVID-19 pandemic. *Journal of Infectious Diseases*, 224(Supplement\_5), S901–S909. Retrieved from: <https://doi.org/10.1093/infdis/jiab473>
- Fertilizer Recommendation Guidebook. (2018). *Fertilizer recommendation guidebook*. Bangladesh Agricultural Research Council (BARC), Farmgate, Dhaka.
- Global Nutrition Report. (2021). *Country nutrition profiles: Bangladesh*. Global Nutrition Report. Retrieved November 20, 2023, Retrieved from: <https://globalnutritionreport.org/resources/nutrition-profiles/asia/southern-asia/bangladesh/>
- Gomez, K. A., & Gomez, A. A. (1984). *Statistical procedures for agricultural research* (2<sup>nd</sup> ed.). John Wiley & Sons.
- Iqbal, J., Khaliq, T., Ahmad, A., Khan, K. S., Haider, M. A., Ali, M. M., Ahmad, N., & Rehmani, M. I. A. (2024). Productivity, profitability, and energy use efficiency of wheat-maize cropping under different tillage systems. *Farming System*, 2(3), Article 100085. Retrieved from: <https://doi.org/10.1016/j.farsys.2024.100085>
- JMP Statistical Discovery LLC. (n.d.). *JMP version 14*. SAS Campus Drive, Cary, North Carolina 27513-2414.
- Mahjabin, T., Jubayer, A., Islam, M. H., Kalam, K. A., Nowar, A., & Khan, M. N. I. (2021). Socio-economic profile and nutritional status of the rickshaw pullers of Dhaka City along with their energy intake gap. *International Journal of Nutrition*, 6(3), 12.
- Ministry of Agriculture (MOA). (2015). *Food and nutrition handbook for extension workers*. Animal and Industry and Fisheries, Ministry of Agriculture, Uganda. Retrieved from: [www.agriculture.go.ug](http://www.agriculture.go.ug)
- Nasim, M., Shahidullah, S. M., Saha, A., Muttaleb, M. A., Aditya, T. L., Ali, M. A., & Kabir, M. S. (2017). Distribution of crops and cropping patterns in Bangladesh. *Bangladesh Rice Journal*, 21(2), 1–55.
- Shaheen, N., Rahim, A. T. M., Mohiduzzaman, M., Banu, C. P., Bari, M. L., Tukun, A. B., Mannan, M., Bhattacharjee, L., & Stadlmayr, B. (2013). *Food composition table for Bangladesh* (1st ed.). Institute of Nutrition and Food Science, Centre for Advanced Research in Sciences, University of Dhaka.
- Zaman, M. A. U., Pramanik, S., Parvin, N., & Khatun, A. (2017). Crop diversification in Rangpur Region. *Bangladesh Rice Journal*, 21(2), 255–271.



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## SUGGESTED CITATION

Islam, S., Cheesman, S., Shanto, M. H., Rahaman, M. A., Hossain, K., Barman, J. C., Gathala, M. K., & Krupnik, T. J. (2024). *Increasing food diversity and nutritional yield: Evaluating diverse cropping systems—A field study in Chapainawabganj District in Bangladesh* (Research Note 43). Transforming Agrifood Systems in South Asia (TAFSSA).

## ACKNOWLEDGEMENTS

We would like to thank all funders who supported this research through their contributions to the CGIAR Trust Fund: <https://www.cgiar.org/funders/>

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## ABOUT TAFSSA

TAFSSA (*Transforming Agrifood Systems in South Asia*) is a CGIAR Regional Integrated Initiative to support actions that improve equitable access to sustainable healthy diets, improve farmers' livelihoods and resilience, and conserve land, air, and water resources in South Asia.

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