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1 Acknowledgments

The research team is grateful to the farmers of northern West Bengal who participated in this research project and enabled us to increase our understanding of wide-row, additive intercropping in this region.

2 Executive summary

Following the recent introduction to the eastern region of the Indo Gangetic Plain in South Asia in a previous ACIAR-funded project (SRFSI), the popularity of wide-sown maize has increased, giving rise to the possibility of additional sustainable agronomic intensification practices. One such option identified was wide-row, additive intercropping. This Small Research Activity (SRA) was undertaken to determine (i) the agronomic potential for wide-row, additive intercropping in the Indo Gangetic Plain, (ii) smallholder farmers' interest in and perceptions of this regionally-innovative intercropping, including any concerns and research challenges identified, and (iii) to plan a research agenda for a larger intercropping project.

There are many potential benefits of wide-row intercropping, including increased cropping system productivity and productivity; water-, labour- and energy-use efficiencies; improved nutrition and food security for rural households; economic empowerment for women; and additional opportunities for smallholder farmers to participate in vegetable-production value chains.

The early research into wide-row, additive intercropping conducted in this SRA suggests that the practice is of strong interest to farmers, providing many with opportunities to increase the efficiency of their dry season cropping systems, and not only increasing cash flow in the dry season but also spacing out the timing of income. As well, farmers valued the additional nutritious vegetables grown on their own farms, in environments they knew were chemical free: this safe addition to household nutrition security contributed to making the practice attractive to farmers who participated in the project.

This SRA has demonstrated the feasibility of wide-row, additive intercropping as a strategy for sustainable and resilient farming systems intensification and diversification in the Indo Gangetic Plain. Through participatory engagement activities and experimental field trials farmers and researchers identified agronomic, social and economic research questions which will be addressed in the larger intercropping project which commenced in May 2023.

3 Background

Replacement intercropping, whereby a portion of the main crop in a field (e.g. wheat) is displaced by a second crop (e.g. oilseed or legume), was widespread in the northern cereal-growing belt of the Indo Gangetic Plains of South Asia until the early 2000s in the dry (rabi) cropping season (Singh et al., 2010). In these subsistence-based cropping systems replacement intercropping was valued as a means of (1) increasing human food security, (2) providing alternative livestock feed, (3) suppressing weeds and insects, (4) efficiently increasing crop water use efficiency, (5) providing employment for farm families when rural labour was in surplus, and (6) increasing the resilience of food-production systems against natural climate variability such as the variations in the wheat sowing date caused by variable onset of the preceding monsoon.

The economic benefits of replacement intercropping were variable and inconsistent and the practice was in only limited use by 2010 (Singh et al., 2010). Following the increased use of machinery and agrochemicals and high labour costs and the change in smallholder production system emphasis from “subsistence farming systems” to “income-focused cropping systems,” farmers pivoted to monocropping dry season fields during the dry season. While a farm might contain several small fields each with a different dry season crop, the main focus is now on producing high-value cash crops such as wheat, and the perception of replacement intercropping is that it penalises the yield and therefore the profit of the main crop (Singh et al., 2010, M. Gathala, CIMMYT, pers comm).

The recent introduction and widespread popularity of maize in the Indo Gangetic Plain cereal belt highlights the potential for an alternative form of intercropping. Compared to wheat, maize is higher-yielding, more input-efficient and more economically profitable, and has proved to be attractive to smallholder farmers in the region (e.g. Islam et al., 2019; Gathala et al., 2021). Maize is planted at wider row spacings than wheat (typically 60 cm instead of 20-22 cm) and is relatively slow-growing when planted as a winter crop. Thus there is an opportunity of about 60-65 days for a short-duration ***additive*** intercrop to be sown between the maize plants without reducing (or displacing) the intensity at which maize plants are sown. This wide-row, additive intercropping has the potential to not only increase cropping system intensity and productivity, but also to increase the nutritional diversity of food grown on smallholder farms, as most potential intercrops are either vegetables or legumes. As well, there is potential to increase both the labour- and water-use efficiency of the dry season crop, as wide-row, additive intercropping yields an additional crop for relatively little additional input.

Wide-row, additive intercropping has been demonstrated to increase cropping system productivity and profitability with reduced environmental footprint in China and South America (e.g. Chai et al., 2021; Lopez-Ridaura et al., 2021) however little is known about how best to implement the practice in South Asia agroecologies to sustainably intensify production systems. Additionally, the effects of wide-row, additive intercropping on women are not well known. It is possible that intercropping would add to female farmers’ workloads (the production of vegetables is generally regarded as “women’s work”) and be an onerous task, or alternatively it might generate new opportunities for income generation and financial independence and recognition within the household and/or community, thus empowering women farmers (Rao, 2020). Thirdly, there is potential for wide-row, additive intercropping to provide additional land to produce livestock feed (either directly or as the by-products of other intercrops such as cauliflower or cabbage).

This Small Research Activity (SRA) was established to investigate the potential (or not) for a full project on wide-row, additive intercropping in South Asia. While conceptually this form of intercropping has potential in any wide-row spaced crop (sugarcane is another potential), research in the SRA focused solely on dry-season maize production in northern West Bengal, India. Two main research activities, experimental field trials and participatory research to better understand farmers’ perceptions of wide-row, additive intercropping, were complemented by a review and planning workshop.

4 Objectives

The SRA was initially established to run for 10 months, from December 2021 to September 2022, and aimed to identify researchable opportunities to address technical, nutritional and social bottlenecks to facilitate wide-row, additive intercropping in the Indo Gangetic Plain in order to inform the development of a larger research project on wide-row, additive intercropping.

The four specific research areas of the SRA were:

1. To determine the agronomic feasibility of wide-row, additive intercropping in wide-sown crops such as dry-season maize;
2. To understand both the general perceptions within farming communities and the perceptions of the men and women farmers who participated in on-farm trials of wide-row, additive intercropping;
3. To identify agronomic, social and other research questions to inform the planning of a larger follow-on project; and
4. To conduct a review and planning meeting to collaboratively outline the range and scope of a follow-on larger project on wide-row, additive intercropping in South Asia.

Of necessity, field trials commenced extremely quickly (approximately 2-3 weeks) after the conceptualisation of this project in order to sow the trials in a timely manner and little pre-sowing planning was possible . While some intercrop treatments were unsuccessful due to the late timing of the experiment the overall response to the trial, including formal feedback through participatory engagement with field trial farmers, was overwhelmingly positive.

A second year of field trials was funded through the project with additional support from the implementing partner, Uttar Banga Krishi Viswavidyalaya in the 2022/23 rabi season. The SRA formally concluded on 30 June 2023.

During the second experimental season additional informal experimental trials were independently run as extension activities by the West Bengal Department of Agriculture around the Siliguri region. These are not reported on here as they are outside the scope of the SRA project (and little formal data were collected on the trials) but responses have been positive and the follow-on project plans to continue to engage with and support the West Bengal Department of Agriculture to promote good agricultural practices around wide-row, additive intercropping.

This SRA project follows on from the introduction of maize into the eastern Indo Gangetic Plain which was undertaken in the ACIAR-funded SRFSI project (CSE/2011/077).

5 Methodology

Field trials were conducted in the 2021/22 rabi season; these were repeated in the 2022/23 season. Experiments were conducted in maize based fields of four famers each around the Coochbehar and Malda research campuses of Uttar Banga Krishi Viswavidyalaya. These were complemented by on-station trials. In each trial sole maize was compared to maize intercropped with a vegetable or legume crop. Three types of intercrops were selected: leafy vegetables, 'heavy feeding' vegetables, and legumes. Following feedback from the first year of trials a revised list of intercrops was tested in the second experimental season. The intercrop species tested in each year at both Malda and Coochbehar are shown in Table 1.

Table 1: Intercrop species tested at Coochbehar and Malda across two rabi seasons

Intercrop type	Intercrop species	Number of farms on which intercrop tested			
		Coochbehar year 1 (21/22)	Coochbehar year 2 (22/23)	Malda year 1 (21/22)	Malda year 2 (22/23)
Leafy vegetables	Amaranthus	1	0	4	4
	Chickpea	0	0	4	4
	Coriander	3	4	4	4
	Fenugreek	3	3	4	4
	Spinach	3	5	0	0
Heavy feeding vegetables	Beetroot	3	0	4	4
	Broccoli	3	5	0	0
	Cabbage	0	4	0	0
	Carrot	1	0	4	4
	Cauliflower	0	2	0	0
	Radish	1	4	4	4
Legumes	Field pea	3	0	4	0
	French bean	3	4	4	4
	Garden pea	3	4	4	4
Sole maize	Sole maize	3	5	4	4

Experimental trials were sown according to a common protocol which aimed to optimise the geometry and crop management in each treatment. In all treatments inputs (e.g. water, fertilizers) were aimed to be non-limiting to examine the performance of the intercropping practice. The inputs and labour required in each treatment were recorded, along with the harvested yield in both the intercrop and maize treatments for subsequent analysis.

Experimental results were reported as maize-equivalent yield (MEY), i.e. the amount of the maize and (where present) the intercrop converted to maize-yield using the equivalent

economic sale prices of both the maize and the intercrop. Considering the field trials in MEY enables more accurate comparison of products of unequal weight (for example spinach and radish yields cannot be meaningfully compared by weight). Experiments were also reported in terms of the cropping system gross margin (GM), i.e. the amount remaining once costs of production were subtracted from the income generated. As well, each cropping system was expressed in terms of its economic efficiency of the labour required and of its protein-yield. There were relatively few data points due to the small number of replications in each trial and so extensive statistical analysis was not undertaken. Results are indicative only, to inform the design and planning of the larger project.

These data were used to inform the planning of a larger research project and a manuscript summarizing the agronomic trials is in preparation and will be submitted to a journal in September 2023.

Three types of **farmer focus group discussions and household interviews** were undertaken in the 2021/22 rabi season: to sample farmers' opinions of wide-row, additive intercropping broadly across the northern West Bengal rural community, and to engage more deeply with those farmers who had participated in the field trials. These discussions were:

1. An online survey of farmer self-help groups in northern West Bengal, to understand rural communities' general perceptions of both traditional (replacement) and wide-row, additive intercropping. Senior representatives from 44 self-help groups participated in the survey.
2. Face to face interviews with 408 farmers randomly selected from rural households across northern West Bengal to gain a greater in-depth understanding of farmers' currently knowledge and perceptions of intercropping, and in particular of wide-row, additive intercropping. Farmers were selected from maize-growing areas but there was no attempt to select participants who did or did not already practice intercropping. Approximately 30 % of farmers had undertaken some form of intercropping in the recent past.
3. Farmers who participated in the on-farm intercropping field trials were interviewed following the harvest of the intercrop but before the harvest of the main maize crop to enable researchers to understand their experiences of participating in the intercropping experiments. Men and women farmers from six households (three around Malda and three around Coochbehar) were separately interviewed, for a total of 12 paired interviews.

The data from these participatory engagement activities were used to inform the planning of a larger research project and a manuscript summarizing the human-centred research is in preparation and will be submitted to a journal in August 2023.

A **review of the literature** on current intercropping practices across the Indo Gangetic Plains was conducted and has been used to inform the planning of the larger research project and the writing of the two journal papers arising from this SRA.

Data from the biophysical and human-centred research informed a high-level **farming systems analysis** of the labour, nutrition, productivity and profitability likely to be generated by wide-row, additive intercropping for smallholder farmers across the Indo Gangetic Plains. Due to the untimely delivery of field trial data more in-depth modelling of farming systems incorporating wide-row, additive intercropping was not possible; this is now deferred to the larger research project, where it will be conducted across a larger geographic region.

A **review and planning workshop** was held in August 2022 with participants from the SRA project, prospective additional partners for the larger project, and relevant expert advisors. This workshop reviewed interim results from first-year research activities and planned the scope and activities to be proposed and undertaken in the larger project.

6 Achievements against activities and outputs/milestones

Objective 1: To identify researchable opportunities to address technical, nutritional and social bottlenecks to facilitate wide-row, additive intercropping in the Indo Gangetic Plain

No	Activity	Outputs/ milestones	Completion date	Comments
1	Field trials	One rabi season (November 2021 to April 2022) of maize-based wide-row additive intercropping with a range of intercrop species to identify key agronomic research questions to address in a larger research project. Field trials will focus on: - Examining the relative performance of three types of intercrop species: leafy vegetables, root vegetables, and legumes; - Assessing changes in key inputs (labour, water, fertiliser, herbicides) under different types of intercrop species relative to sole maize.	April 2022	Completed. Field trials were undertaken in both Malda and Coochbehar to examine differences between three different types of intercrop species in terms of inputs required and rabi-season cropping system productivity. The outcomes from these trials informed the planning of research activities in the larger project. Following successful field trials in the 2021/22 rabi season and due to high farmer interest the field trials were extended to a second rabi season in 2022/23. This uncosted extension to the field trials was made possible by generous support from Uttar Banga Krishi Viswavidyalaya. Also in the 2022/23 rabi season the West Bengal Department of Agriculture initiated additive intercropping trials around Siliguri.
2	Farmer focus group discussions and household interviews	Understanding of men and women farmers' perceptions of the opportunities, benefits, risks and challenges associated with wide-row, additive intercropping. Key social and economic research questions to address in a larger research project.	April 2022	Completed. Farmer participatory engagement activities were undertaken at three scales (self-help groups, general farming community, and field trial participating farmers) to understand farmers' perspectives on wide-row, additive intercropping and to inform planning research activities in the larger project.
3	Literature review	Informed understanding of current intercropping practices across the Indo Gangetic Plains.	July 2023	Completed. Relevant literature on intercropping across the Indo Gangetic Plains has been reviewed and this activity informed planning the larger project and the writing of two manuscripts summarizing SRA research activities.
4	Farming systems modelling	Identification of further research questions to identify in a larger research project in terms of the likely farm-level impacts on labour, livestock, household nutrition, farming system productivity, profitability and climate change resilience of wide-row, additive intercropping.	July 2023	Partially completed. Due to delays in finalizing the field trial data it has not been possible to undertake farming systems modelling. Instead analysis of the farm-level impacts of additive intercropping on household nutrition, labour, productivity and profitability has been undertaken. Systems modelling for a greater range of agroecologies is now a milestone in the larger project.
5	Planning workshop	Peer review of SRA results. Plan a larger project.	August 2022	Completed.

7 Key results and discussion

7.1 Field trials

Overall field trial results suggested that maize intercropped with many leafy or heavy feeder vegetables, or with legumes, are likely to achieve significantly higher maize-equivalent yields (MEY), gross margins (GM) and improved efficiency of labour. These data have not yet been statistically analysed and it is anticipated that initial analyses will be confirmed following both further analysis of these data and of the bigger datasets to be generated in the larger intercropping project.

Some variability in the field trial data is associated with these intercropping experiments being learning opportunities for both the farmers and the researchers engaged in the trials. Other factors, such as use of poor-quality seed or inopportune sowing, also contributed to higher-than-expected variability.

Maize equivalent yields

Across both rabi seasons and at both experimental locations, the majority of intercropped treatments achieved a comparable or higher MEY than sole maize (Figure 1). Exceptions to this in year 1 were field pea and beetroot, the latter of which did not result in any crop product. In year 2 farmers chose not to grow field pea and care was taken to use higher-quality beetroot seed in a more timely sowing. In particular, MEY for maize intercropped with broccoli, French bean and garden pea were significantly higher than the MEY for sole maize, even with relatively small experimental replications.

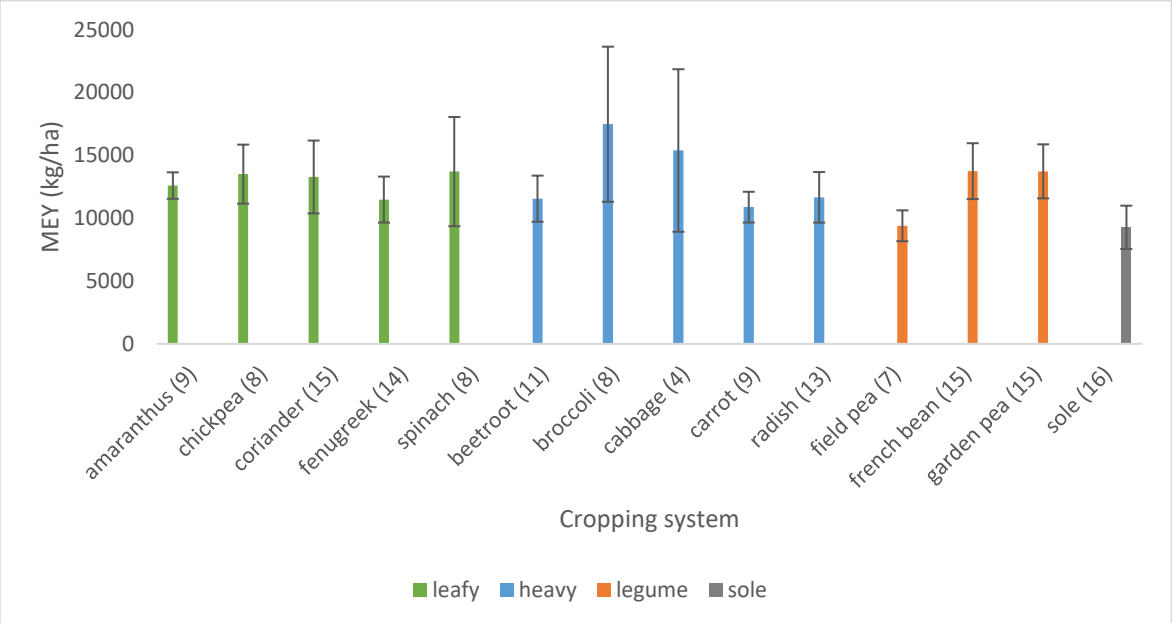

Figure 1: Cropping system maize-equivalent yields. Numbers in parentheses indicate the replications across two years and two locations for each treatment. Error bars show one standard deviation from the mean.

Gross margins

Cropping system GMs were comparable or higher in all intercropped treatments compared to those of the sole maize treatment (Figure 2). In particular some leafy vegetables (e.g. spinach) and some heavy feeding vegetables (e.g. broccoli) had higher GMs than that of sole maize. The price of vegetables can be highly variable within a rabi season even at one location, which can affect the variability of GMs. Care will need to be taken in the larger project to ensure that production of (relatively) large amounts of certain vegetables at key times does not depress their marketable value. Additionally, some

intercrop species, such as legumes and some heavy feeder vegetables, will be able to be stored for a short time, while others such as leafy vegetables will need to be eaten and/or transported to market and sold without delay. The choice of intercrop vegetables will depend on farmers' preferences as well as distance to market and availability of storage facilities.

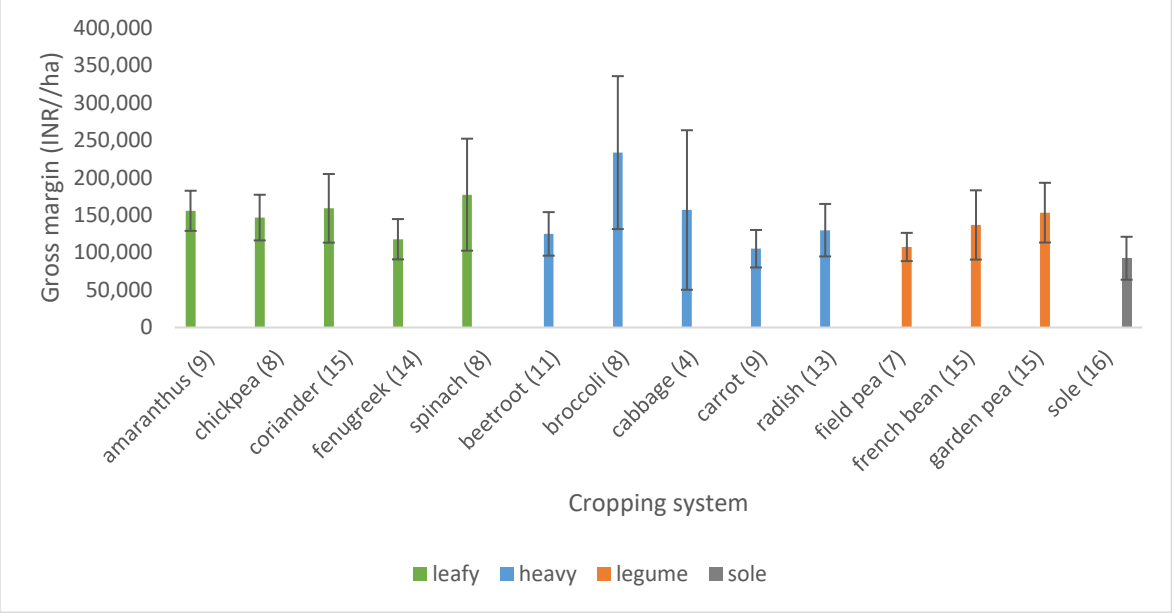

Figure 2: Cropping system gross margins. Numbers in parentheses indicate the replications across two years and two locations for each treatment. Error bars show one standard deviation from the mean.

The monetary efficiency of labour expenditure (i.e. an indication of the GM achieved for the economic-equivalent of the labour required) was higher than in the sole maize crop for the spinach, broccoli and cabbage intercrop systems, and was comparable for most other intercrop systems (Figure 3). In the chickpea and carrot intercrop systems the monetary efficiency of labour expenditure was worse than in the sole maize cropping system. While these early results are promising, additional research is required into labour efficiency in different intercropping systems.

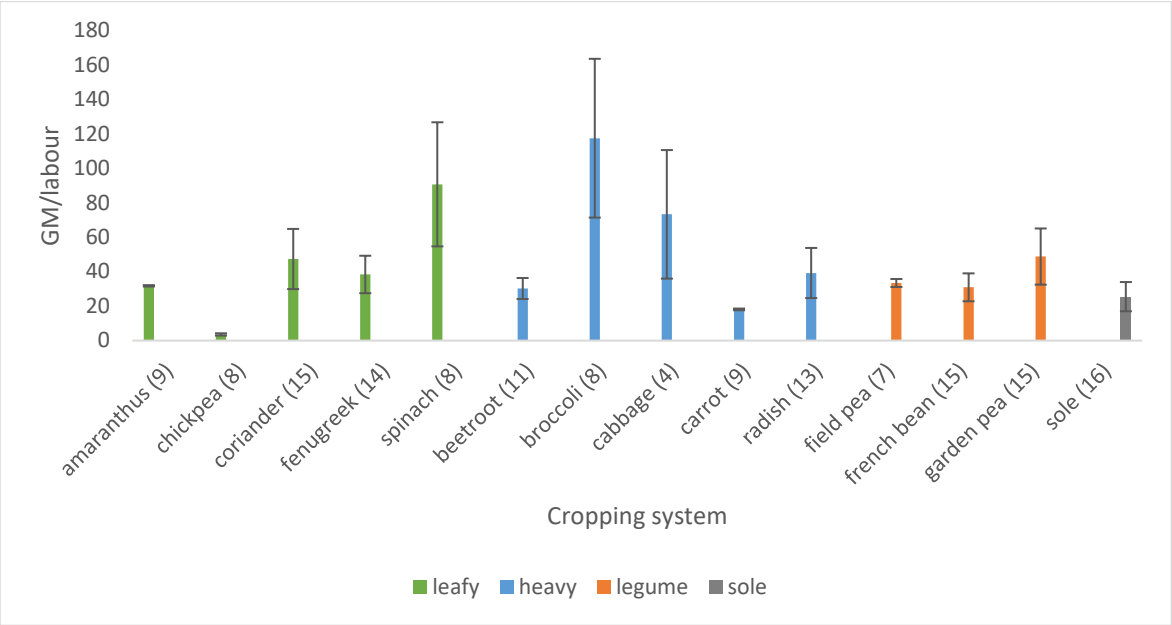

Figure 3: Cropping system monetary efficiency of labour expenditure. Numbers in parentheses indicate the replications across two years and two locations for each treatment. Error bars show one standard deviation from the mean.

Key learnings

Non-chemical weed suppression will be important in effective wide-row, additive intercropping. It is possible that intercrops may be regarded by farmers as a cost-effective method of weed suppression which also brings additional food and cash-crop benefits, particularly if the cost of agrochemicals continues to increase. Intercrop species which grow fast are likely to be attractive.

The potential for intercrops as animal feed was not directly tested in this SRA, although some farmers noted that they fed crop by-products to livestock. This may be particularly relevant in, for example, sugarcane production systems where households struggle to source high-quality livestock feed and often resort to feeding sugarcane tops which are ultimately deleterious to ruminant health.

7.2 Participatory research activities

Survey 1 results

Senior representatives from 44 farmer self-help organisations participated in the online survey. Most (39) were aware of any form of intercropping but little was currently being undertaken. In 60 % of farmer organisations less than 10 % of households had undertaken some intercropping in the last two years.

Survey 2 results

Farmers who had previous experience in intercropping were largely more positive towards the practice than those without (Figure 4). Over 90 % of farmers who intercropped perceived an increase in the amount and variety food available for the household, compared to approximately 75 % of those who had not intercropped. Similarly, 85 % of intercropping farmers felt the practice increased household profitability or income, while only 55 % of non-intercrop farmers identified this as a potential benefit. Intercrop farmers were also more aware of the additional labour and inputs required in intercropping than non-intercrop farmers. Up to 70 % of intercrop farmers perceived that the practice reduced their climate risk, while only 50 % of non-intercrop farmers perceived a reduction in climate risk with intercropping. 65 % of intercrop farmers perceived little change in maize production under intercropping, while only 45 % of non-intercrop farmers anticipated little change in maize production.

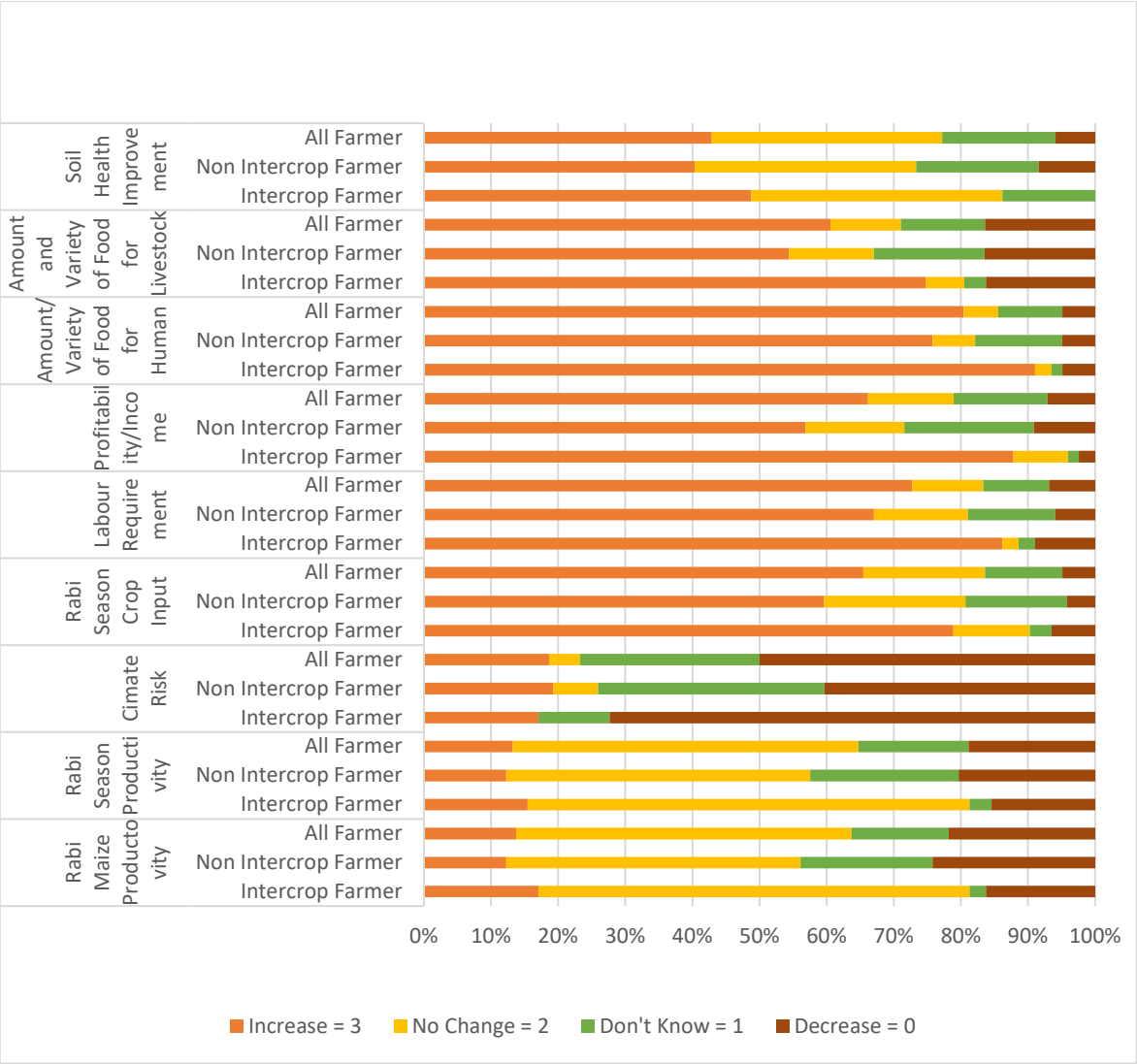

Figure 4: Farmers' preferences for different aspects of intercropping

Survey 3 results

More strongly than women (and given the limited sample size), men perceived increased rabi season productivity under wide-row, additive intercropping, with reductions in climate risk and in pests, disease or weeds (Table 2). Both men and women felt it likely that additional inputs (water, fertilizer) would be required in an optimally-managed intercropped maize crop, and were keen for additional information and agronomic recommendations. While both men and women perceived additional labour requirements under intercropping, they also saw increases in seasonal income/profit, and in the amount of food available to the household.

Table 2: Farmers' perceptions by gender of the effects of wide-row, additive intercropping

Does wide-row, additive intercropping affect…	Respondent gender	No change	Increase	Decrease	Don't know
…rabi productivity	Women	2	3	1	
	Men		6		
…climate risk	Women	4	1		1

Does wide-row, additive intercropping affect…	Respondent gender	No change	Increase	Decrease	Don't know
	Men		1	5	
…pests/disease/weeds	Women	2	1	2	1
	Men	3		3	
…crop inputs	Women	1	2	1	2
	Men	2	3	1	
…labour	Women	1	4		1
	Men		6		
…rabi income/profit	Women		4	1	1
	Men		6		
…amount/variety of human food	Women		6		
	Men		6		
…amount/variety of animal feed	Women	2	4		
	Men	1	4		1

Farmers were positive about the economic benefits of wide-row, additive intercropping in maize, and had two different ways of describing these benefits. For some farmers, the intercrop was a form of 'insurance' for the main crop – if the maize yield were negatively affected (e.g. by a cyclone or other weather event) selling part of the intercrop had covered their costs of maize production; any money achieved from selling maize (in both bad and good years) was pure profit. Other farmers felt that the costs of producing the intercrop had largely been covered in establishing and producing the maize crop and so the intercrop was produced extremely efficiently, and could be used for both home consumption and to sell as a high value cash crop. All households intended to intercrop in the future, and all participated in the second season of the experimental trials, with modifications to the intercrops grown in some cases (e.g. field pea) in response to perceived poor growth in the first season.

Farmers perceived nutritional and food security benefits from intercropping: they liked having access to fresh, high quality vegetables and knowing they had been grown without pesticides. All households ate some of the intercrop produced and sold part of the produce. In 80 % of households by-products were used as livestock feed.

Both men and women farmers identified the appropriate intercrop selection and timing of sowing both the maize and intercrop as key challenges of wide-row, additive intercropping. Men also perceived challenges in adequately suppressing weeds without using chemicals, in defining optimal fertilizer and irrigation practices for both intercrop and maize crop, and in optimally spacing both crops within the field. Price variability and low prices (due to late sowing of the experiments) were cited as other potential negative aspects of intercropping. These are all challenges which will be addressed in the larger intercropping project.

Men and women had differing perceptions of the household farm: both stated that the households kept cows, chickens, goats and ducks, but only men reported fish as a household product. Fish cultivation and harvest is a male activity and may happen away from the family home, while the cultivation of other livestock is likely to be visible around the home, even if the labour involved is likely to be largely women's labour. Similarly, women's perceptions of the size of land the household farmed differed significantly from their husbands' estimates (women are more likely to provide menial labour on the farm but to be less involved in farm-level decision making). There was inconsistency in men's and women's perceptions of who undertook which cropping system activities, but all agreed that men marketed and sold household products.

Key learnings

In the general farming community there is widespread awareness of intercropping in general, but little understanding of additive intercropping specifically. Farmers generally perceive there may be some benefits to the practice, but there is consistently an approximately 20 % difference in the understanding of the benefits and nuances of intercropping between those who have and have not undertaken intercropping recently.

The farmers who participated in the SRA field trials were interested in wide-row, additive intercropping, and in accessing additional information regarding optimal agronomic management and value chain intervention points to enable farmers to successfully intercrop in their maize crops.

8 Impacts

Broadly the SRA has generated awareness of the potential of wide-row, additive intercropping in the research and agronomic community in West Bengal. The greatest impacts from this project are likely to be achieved in combination with those achieved through the larger intercropping project (which commenced in May 2023).

8.1 Scientific impacts – now and in 5 years

This SRA has underpinned the development and commissioning of the larger intercropping project, which is operating in at least two countries (Bangladesh and India; it is hoped Bhutan will shortly join the project) and focussing on wide-row, additive intercropping in two key crops, maize and sugarcane. There is strong potential for wide-row, additive intercropping to sustainably intensify food system production in the Indo Gangetic plain and thus to increase households' nutrition and food security and income.

Two manuscripts reporting on the participatory engagement research and the field trials and are in the late stages of writing and will be submitted to journals in August and September 2023, respectively. Through this dissemination of the research via academic channels additional scientific impacts are anticipated as other researchers become aware of the potential for wide-row, additive intercropping in South Asian farming systems.

8.2 Capacity impacts – now and in 5 years

Capacity impacts from this SRA will be achieved in combination with those achieved through the larger intercropping project, in particular around cropping/farming systems analysis (including modelling), agronomic research, household nutrition, and opportunities for rural women.

The West Bengal Department of Agriculture supported farmers near Siliguri to participate in additional field trials in the 2022/23 rabi season. These farmers have large marketing opportunities of high value cash crops into Siliguri, and are eager to intensify their dry season production systems. They also request information and additional capacity building on appropriate crop management practices.

8.3 Community impacts – now and in 5 years

Through community dialogues and discussions with neighbouring farmers interest has been generated in wide-row, additive intercropping. This, combined with ongoing research in the larger project, is likely to generate community impacts which will be documented in detail in the larger project. These may include: economic impacts for cash-crop oriented farmers, especially those close to large markets, and for livestock farmers who are otherwise challenged to supply their animals with high quality feeds; social impacts for women entrepreneurs and others to engage in intercrop value chains in addition to on-farm production; and environmental impacts as fewer agrichemicals are required to produce maize (or other wide-row) crops when intercrop species may be used to suppress weeds.

8.4 Communication and dissemination activities

The concept of wide-row, additive intercropping was disseminated at district level around Malda and Coochbehar through workshops undertaken with farmers in August 2022.

High-level summaries of SRA research have been shared with policymakers, extension agencies and research and development organisations in Bangladesh, Bhutan and India.

9 Conclusions and recommendations

9.1 Conclusions

Early research conducted in this SRA suggests that there are many benefits for smallholder farmers across the Indo Gangetic Plain from wide-row, additive intercropping. The SRA has also highlighted a research agenda along six key points:

- Participatory engagement with rural households;
- Agronomic trials (both on stations and on farmers' fields);
- Understanding the effects of intercropping on household nutrition;
- Understanding the effects of intercropping on women's empowerment;
- Value chain opportunities for smallholder farmers; and
- Scaling research for effective dissemination and to maximise the effectiveness of donor funding.

This SRA focussed on maize as the wide-spaced crop into which intercrops were sown; other crops may also be suitable for this intensification through intercropping.

9.2 Recommendations

Early agronomic research has indicated different benefits and challenges for different intercrop species within West Bengal alone; as well there are different social and cultural preferences which vary across the region. It is likely that different intercrop rotations will suit different agroecologies and different typologies of rural households, and these differences should underpin future research into wide-row, additive intercropping.

It is recommended that the larger intercropping project examine wide-row, additive intercropping in terms of the six points identified above, for maize and sugarcane main crops, and across a range of agroecologies and countries within the Indo Gangetic Plain.

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10.1 References cited in report

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10.2 List of publications produced by project

Ghosh, A., Bhattacharya, P., Chowdhury, P., Das, K.K., Dhar, T., Medda, P., Sinha, A., Mitra, B., Biswas, P., Das, A., Gathala, M., Laing, A. *Seeing is believing: Participatory engagement shows farmers, researchers and funders the benefits of innovative agronomic management.* In preparation, to be submitted by 31 August 2023.

Bhattacharya, P., Chowdhury, P., Das, K.K., Dhar, T., Ghosh, A., Medda, P., Sinha, A., Mitra, B., Biswas, P., Das, A., Gathala, M., Laing, A. *Wide-row, additive intercropping sustainably increases farmers' productivity and profitability in eastern India.* In preparation, to be submitted by 30 September 2023.

11 Appendixes

11.1 Appendix 1:

This report will be amended with both manuscripts as appendices when they have been published.