Wastewater Agriculture in Rajshahi City, Bangladesh

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2007

WASPA Asia Project Report 9

This report in one in a series of project reports written by the Wastewater Agriculture and Sanitation for Poverty Alleviation in Asia (WASPA Asia) project. The WASPA Asia project aims to develop and test solutions for sanitation and wastewater management, to reduce the risks form wastewater use in agriculture. The approach involves the development of stakeholder coalitions at town and national level, called Learning Alliances, which will bring together the main stakeholders into a participatory process through which actions will be planned and implemented in a sustainable manner.

These project reports are essentially internal documents intended to inform the future activities of the project, particularly in relation to the development of Learning Alliances and participatory action plans. The reports have been made publicly available as some of the information and findings presented in them may be of use to other researchers, practitioners or government officials.

The WASPA Asia project is funded primarily under the EU Asia Pro Eco II Programme of the European Commission. It is being undertaken by the International Water Management Institute (IWMI), Sri Lanka; COSI, Sri Lanka; the International Water and Sanitation Centre (IRC), the Netherlands; NGO Forum for Drinking Water Supply and Sanitation, Bangladesh; and the Stockholm Environment Institute (SEI), Sweden. The project pilot cities are Rajshahi City in Bangladesh and Kurunegala City in Sri Lanka.

The WASPA Asia Project is funded under the EU Asia Pro-Eco Programme.

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Acronyms and Abbreviations

CHD	Circuit House Drain
DAE	Department of Agriculture Extension
DD	Dargapara Drain
FGD	Focus Group Discussion
IWMI	International Water Management Institute
MOP	Muriate of Potash
PRA	Participatory Rural Appraisal
RCC	Rajshahi City Corporation
RDA	Rajshahi Development Authority
TSP	Triple Super Phosphate
WASPA	Wastewater Agriculture and Sanitation for Poverty Alleviation

1 Introduction

This report presents an assessment of agricultural practices in Rajshahi City, Bangladesh, which was undertaken as part of the Wastewater Agriculture and Sanitation for Poverty Alleviation in Asia (WASPA Asia) project, funded by the European Commission under its Asia Pro Eco II Program. The WASPA Asia project developed out of a global survey on wastewater irrigation and agriculture practices, which was conducted for the Comprehensive Assessment program of the International Water Management Institute (IWMI). As a result Rajshahi City, and Kurunegala City in Sri Lanka, were chosen to be pilot study cities under the WASPA Asia project.

The objective of the project is to improve the livelihoods of urban and peri-urban farmers who are using wastewater in agriculture; and the communities who are responsible for producing the wastewater or consuming the agricultural produce. To do this a holistic approach and sustainable solutions are required along the whole chain of wastewater production, management and use; from improved sanitation to contaminant reduction, waste treatment, disposal, safe use in agriculture and promotion of hygiene behavior.

Before any such changes can be proposed or implemented it is necessary to have an understanding of the current conditions prevailing in the urban and peri-urban area of the two project research cities. These include; current agricultural practices; the quality of wastewater being utilized for agriculture; the impact of that use on agriculture and potential risks to health; sanitation conditions in the city; and the institutional and policy setting within which this takes place. To achieve this, a number of related studies have been undertaken under the WASPA Asia project, the results of which have been presented in a series of reports. This report presents the findings for the agricultural assessment conducted in Rajshahi in 2006-2007. The findings of this study will also be combined with the findings of the stakeholder analysis, the water quality assessment and the sanitation assessment, to produce a more comprehensive report for Rajshahi City.

The WASPA Asia project will work with relevant stakeholders to develop participatory action plans to address issues relating to wastewater agriculture in Rajshahi and Kurunegala, and to learn lessons for other similar cities across Asia. This agricultural survey report will provide important information for the development of those participatory action plans. It will also provide a baseline against which to monitor the impacts of project interventions or other changes that may take place in the city during the project period.

Objectives

The specific objectives of the agriculture assessment were:

- To understand the activities and practices of farmers in the urban and peri-urban areas of Rajshahi City, including farmers who irrigate with wastewater and clean water (ground water).

- To explore the differences between the practices, if any, of these two farming groups and to determine whether there are additional constraints to wastewater irrigation as compared to clean water (CW) irrigation.
- To understand the problems of nutrient management in the field when nutrient concentrations in irrigation water are highly variable, and to consider whether or not fertilizer application reflects these differences, or whether there is potential to alter fertilizer practices to obtain the most benefit from the wastewater nutrients.
- To investigate whether current agricultural practices are optimal and are taking advantage of the benefits of using wastewater whilst mitigating the potential negative impacts; or whether suggestions could be made to improve them.

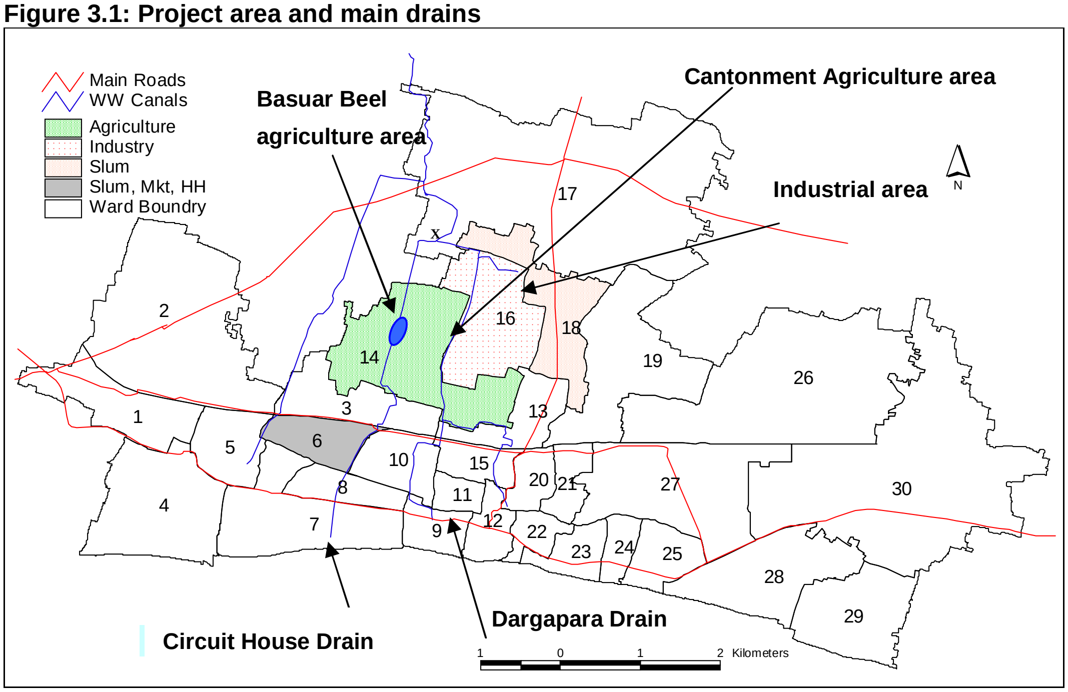
2 Background

Drainage Network and Agricultural Area

A detailed map of the project area was produced using Arc View 3.2 GIS software by incorporating layers given by Rajshahi City Cooperation (RCC). GPS data and Google Earth, and was used to understand the site better (Figure 3.1 and Figure 3.2).

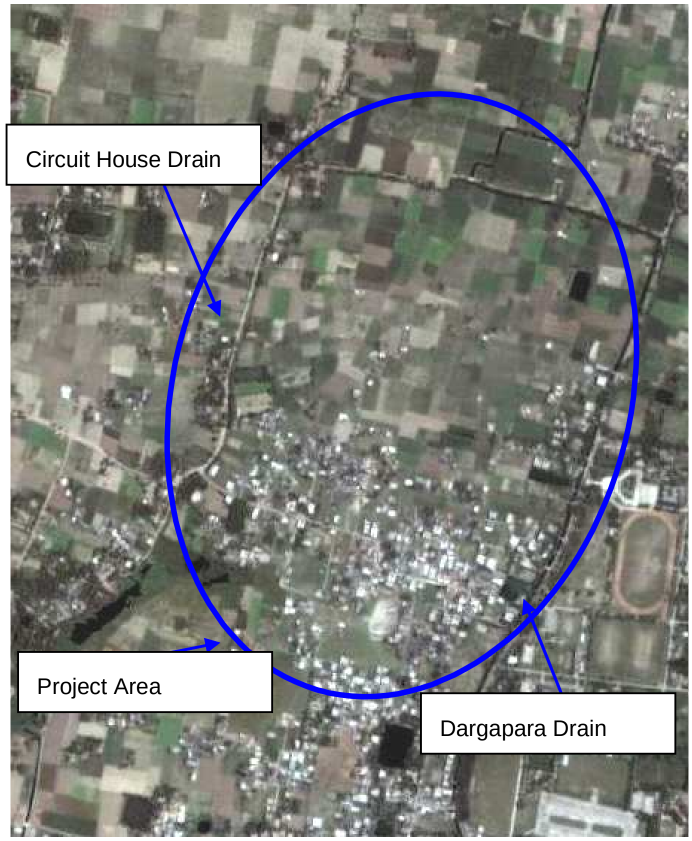
Rajshahi City has an extensive drainage network, which was designed to receive storm water drainage, but studies undertaken as part of this project have revealed that they also contain domestic waste including septic tank over-flow and waste from small-scale industries and commercial units, as well as being used to dispose of solid waste. There are several main drains passing through the city and flowing to the Baranai River in the north of which three flow through an area of 98 ha in which intensive agriculture is practiced by some 247 farmers. These drains are called Circuit House Drain (CHD) and Dargapara Drain (DD) and Keshobpur Drain. Of these the first two flow through the area selected for the WASPA Asia project (Figure 3.1).

Figure 3.1: Project area and main drains



Source: RCC 2006

Figure 3.2: Arial view of the selected agricultural area



Source: Google Earth 2007

3 Methodology

Site Selection and Situation Analyses

A situation analysis was conducted using Participatory Rural Appraisal (PRA) tools such as focus group discussions (FGDs), transect walks, interviews with the farmers, and mapping. The FGDs were conducted with the farming community; and one-to-one meetings were conducted with relevant officials, such as staff from the Department of Agriculture Extension (DAE) and RCC. These stakeholders had been identified in the stakeholder analysis, undertaken as part of the project, as being the key stakeholders for wastewater irrigation in Rajshahi City[1].

Two transect walks were carried out with the same people along the wastewater agricultural area to provide an initial understanding of the system. Cropping patterns, seasons and irrigation activities were documented during these visits, and key informant interviews were undertaken in parallel to the transect walk to confirm some of the observations.

Questionnaire Survey

Using the knowledge from the PRA exercises a questionnaire was designed to better understand the: socio-economic characteristics of the users; history and pattern of wastewater use; land holdings; land use; cropping patterns; farm inputs (water, fertilizer and pesticides) and outputs (yields or returns); comparative prices of wastewater and non-wastewater produce, where available; and farmer perceptions of the advantages and disadvantages of wastewater use.

Households were randomly selected for interview from household lists using SPSS 10 statistical software. Two cropping areas along CHD and DD were identified from the whole wastewater irrigated command area. Farmers were grouped according to the spatial distribution of the two cropping areas and stratified random samples were selected from each (Table 3.1). Sixty farmers from the CHD area and 30 from the DD area were selected for the survey, as well as 40 farmers from an adjoining clean water farming area for comparison.

Table 3.1: Sample farmers for wastewater area

Agriculture area	Number of Farmers	Number of farmers selected for survey	Extent (ha) of selected farmers
CHD area	164	60	67
DD area	83	30	31
Clean water area	Unknown*	40	25
Total	247	90	98

*A large number of people are involved in farming in this area and it was felt that it was unnecessary to try to determine the total number.

[1] For further information on the relevant stakeholders see the Rajshahi Background Report and the institutional analysis report also written as part of this project (Clemett et al. 2006; Ara et al. 2007).

4 Results and Discussion

Household Information

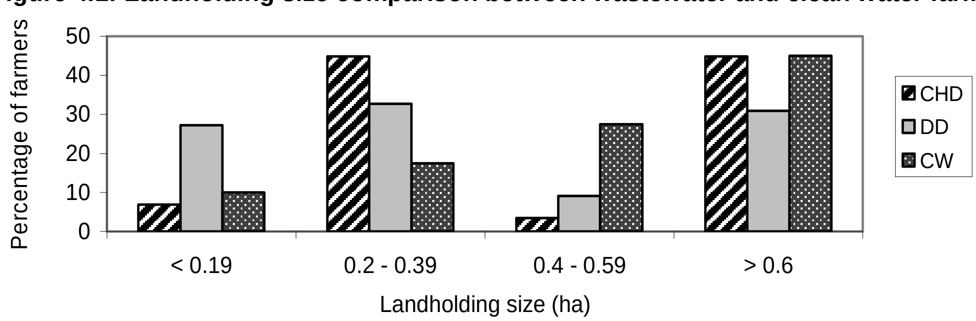
All the household heads who cultivate in the wastewater irrigated area and the clean water area are male. In the wastewater agriculture area the age of the household head varies from 20 to 90 with the majority (58%) being 40 years of age or more. In the clean water area the age of the household head varies between 25 to 60 and 64% of household heads are over 40 years of age. In the wastewater area, most of the farmers (65%) have at least 20 years of farming experience and in the clean water area this figure is 58%. This indicates that these farmers know the quality and condition of their plots well and are likely to have witnessed changes over the past 20 years.

Family sizes vary from 2 to 7 with the majority of households having 5 members or more (59% and 57% in the wastewater and clean water areas respectively). These large family sizes may lead to problems when land is allocated to offspring as the households already have small plots. However, family labor is important with 61% of the dependents in the wastewater area and 71% in the clean water area helping with farming.

Land Ownership and Landholding Sizes

Farmers in the clean water and DD areas have similar sized plots averaging 0.64 ha and 0.68 ha respectively, compared to an average in the CHD area of 0.45 ha (Figure 4.1). It was observed that small plots are always used for cash crops like vegetables, while paddy, sugarcane and jute are grown on larger plots.

Figure 4.1: Landholding size comparison between wastewater and clean water farmers



The data shows that ownership is much higher in the clean water area with 93% of farmers owning their land compared to an average of 50% in the wastewater area. This is likely to relate to the closer proximity of the wastewater area to the city where land prices are higher and were people may own land as an investment to develop at a later date but in the mean time rent it out for cultivation.

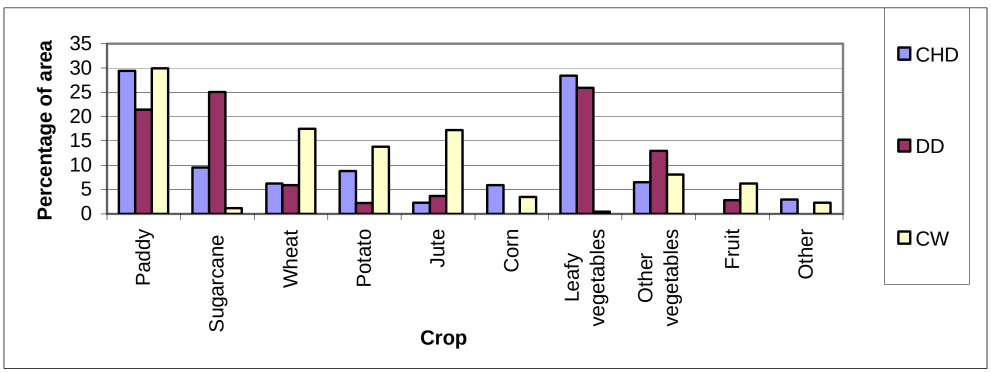
Soil Types

Farmers were asked to describe the soil type of their land. Most of the plots in the clean water area are in the clay soil category (59% of the sample) but in the wastewater area the majority of plots (75%) are within the loamy soil category and the rest are clay soils. Loamy soils are generally fertile and well-drained, containing clay, sand and a significant amount of organic matter, hence the wastewater irrigated lands are suitable for a wide variety of crops.

Cropping Patterns

Both wastewater and clean water farmers grow various crops through-out the year, although the crops in the two areas differ slightly. Paddy and wheat are grown in both areas but leafy vegetables and sugar cane are almost exclusively grown in the wastewater irrigated area (Figure 4.2). This is likely to be because these crops require regular, large amounts of water, which is readily available from the wastewater drains. Wheat, potato and jute are grown in the clean water area but to a much lesser extent in the wastewater areas.

Figure 4.2: Comparison of extent of crops grown in wastewater and clean water areas



Paddy

Several paddy varieties are grown in both clean water areas and wastewater areas although *parija* and Indian *purbachi* are grown only in the wastewater areas (Table 4.1).

Table 4.1: Paddy varieties grown in wastewater areas and clean water areas

Paddy variety	Duration (months)	Seasons	Yields (ton/ha)
BRRI Dhan-28	5	Kharif-1	5-7
BRRI Dhan-32	4	Kharif-2	4-6
BR-21	4	Kharif-1	4-6
BRRI Dhan-29	5	Robi	5-7
BRRI Dhan-28	5	Robi	5-7
BRRI Dhan-30	5	Kharif-2	5-7
Parija	5	Robi and Kharip-1	5.5
Indian Purbachi	5	Robi and Kharip-1	5

Univariate analyses were carried out using SPSS.10 statistical software to compare the yields in the three areas. The results show that there is a significant deference (P<0.05) between clean water and wastewater yield with an average yield of 3.9 tons/ha in the wastewater area and 4.7 tons/ha in the clean water area (Table 4.2).

Table 4.2: Yield difference between wastewater plots and clean water plots

Type	Area	Mean (kg/ha)	P<0.05
Clean water	CW	4665	0.003
Wastewater	DD	4056	
	CHD	3740	

This difference in yield could be attributed to a number of factors including:

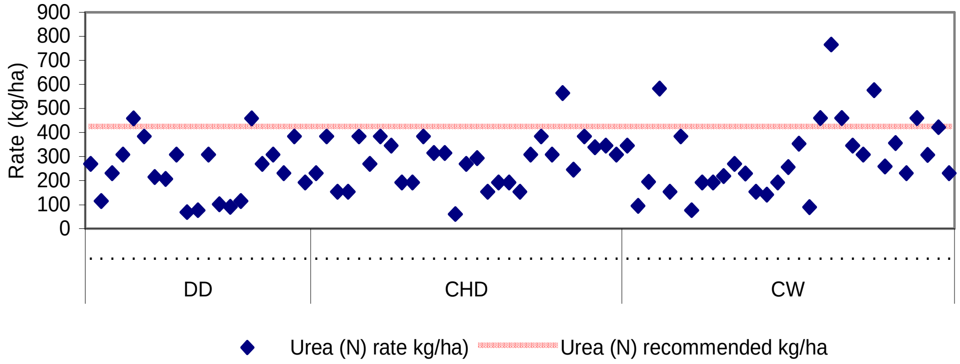
- The smaller plot sizes, especially in CHD;
- The different rice varieties;
- The different soil types;
- The salinity levels of the wastewater compared to ground water;
- Differences in nutrient availability (in wastewater or agro-chemicals); or
- Farming practices, because the clean water farmers grow more rice and may therefore have greater expertise in growing this than the wastewater farmers who grow a variety of crops.

The current study could not definitively determine the cause, which requires further investigation.

Fertilizer Application

Information on fertilizer application is provided by the DAE for a whole range of crops. When the farmers were asked how much they apply it became apparent that urea is under-applied by almost all farmers in all areas, although the number that over-apply is higher in the clean water area (Figure 4.3). This is surprising as urea is subsidized by the government.

Figure 4.3: Urea (N) application rates and recommended levels for rice



By contrast application rates of Muriate of Potash (MOP, which contains potassium) and Triple Super Phosphate (TSP) were well above the recommended level in all areas by the majority of farmers (Figure 4.4 and Figure 4.5).

Figure 4.4 MOP application rates and recommended levels for rice

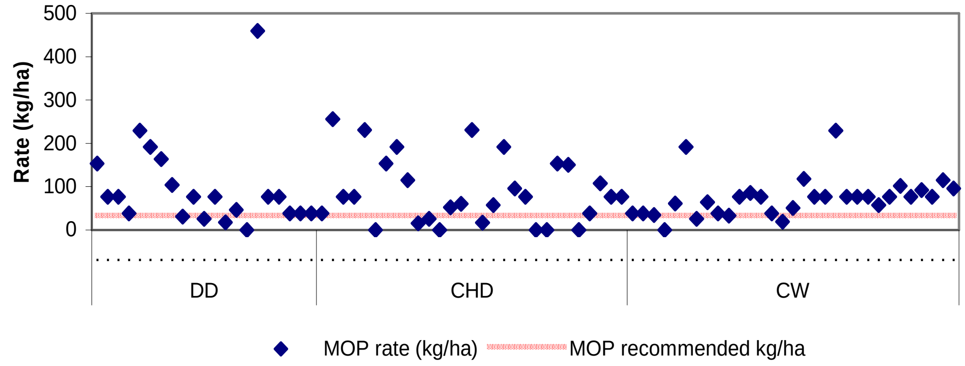
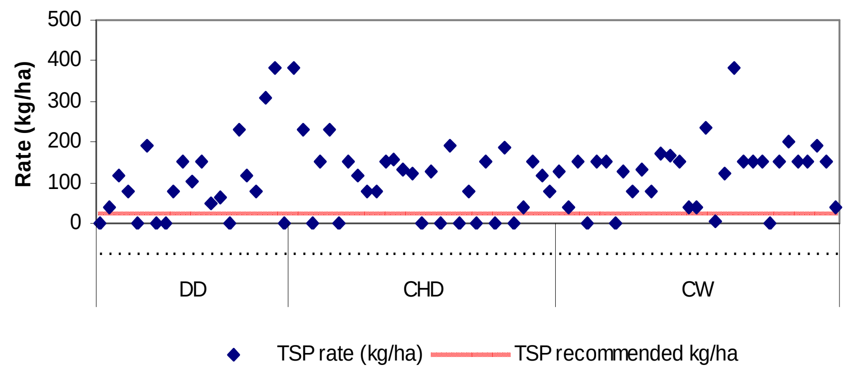


Figure 4.5 TSP application rates and recommended levels for rice



The quantities of MOP applied in the wastewater area appear to be higher than in the canal water area, which is supported by statistical analysis (Table 4.3). There is however no statistically significant difference between the application of urea and TSP in the three areas.

Table 4.3: Fertilizer use in wastewater and clean water areas

Fertilizer	Mean Average (kg/ha)			Significance
	DD	CHD	CW	P
Urea	243	283	300	0.269
MOP	101	104	74	0.084
TSP	141	145	74	0.556

This finding was considered unusual and further attempts were made to determine whether or not it was correct. So far evidence suggests that it is but the investigation is continuing.

Organic Fertilizer

Organic fertilizers play an important role in maintaining the long term fertility of rice fields by improvement of the physical and biological properties of the soil; but farmers in Rajshahi hardly use organic fertilizer. From the sample, only six farmers (two for each area) use organic fertilizer (cow dung) but FGDs revealed that some farmers use household waste. It is said that the farmers are reluctant to use organic fertilizer in Rajshahi because

- Organic fertilizer is simply not as popular as chemical fertilizer;
- Markets selling organic fertilizer are rare which means that the farmer must have his own source e.g. livestock;
- Farmers are not aware about the nutrients in organic fertilizer; and
- Farmers think that the wastewater contains a good amount of organic matter which will meet their demand.

Agrochemicals, Pests and Diseases

Agrochemical applications in DD and CW areas appear to be much lower than in the CHD area where as many as 92% of the farmers who responded to the question used fungicide, compared to 48% in Dargapara Drain area and just 13% in the clean water area (Table 4.4). In terms of weedicide the highest use was in the clean water area but this was only a little more than in the Circuit House Drain area; but it is interesting to note that no one in DD area said they use weedicide. As with fertilizer application these differences are not easily understood but it is possible that the availability of water in the drainage water areas is sufficient for them to use excess water as a means to kill weeds, whereas this is not possible in the ground water area. Perhaps this also links to the higher use of fungicide in the wastewater areas.

Table 4.4: Number farmers who use agro-chemicals

Agro chemicals	DD	DD (%)	CHD	CHD (%)	CW	CW (%)
Weedicide	0	0	27	45	20	50
Insecticide	10	34	46	77	10	25
Fungicide	14	48	55	92	5	13
Number of farmers in the sample answers	29		60		40	

Interestingly, although the percentage of farmers in the CHD area using insecticide was high, the percentage reporting pest attacks and diseases was low. Generally stem bore attack was found to be the main problem in all three areas with Rice Hispa attack being prominent (41%) in the DD area (Table 4.5).

Table 4.5: Cases of pest attack in the clean water and wastewater areas

Pest and disease attack	Percentage of farmers reporting pest attacks		
	DD	CHD	CW
Stem borer	65%	25%	75%
Grass hopper	3%	0%	0%
Rice hispa	41%	1%	13%
Cutworm	0%	1%	5%
Number of farmers in the sample who gave answers	29	60	40

Consumption

Most of the farmers in the wastewater agriculture area use their whole paddy yield for home consumption due to small land holdings. Clean water area farmers have comparatively larger lands and are able to sell a portion of their yield. When produce is sold in the market, there is no significant difference between prices for wastewater and clean water products, with an average price for rice being 10 taka per kilogram in 2006.

Wheat

Out of the 129 farmers interviewed only 36 farmers (6 DD area, 9 CHD area and 21 CW area) grow wheat on a total of around 12 ha of land.

Yield

Comparison of yields was carried out between clean water farmers and wastewater farmers using univariate analyses in SPSS.10. The results show that there is no significant deference between ($P<0.05$) between yields in the two areas (Table 4.6).

Table 4.6: Yield difference between wastewater plots and clean water plots

Type	Mean Yield (kg/ha)	Standard deviation	P<0.05
Clean water	3396	825	0.872
Wastewater	3352	788	

Fertilizer Use

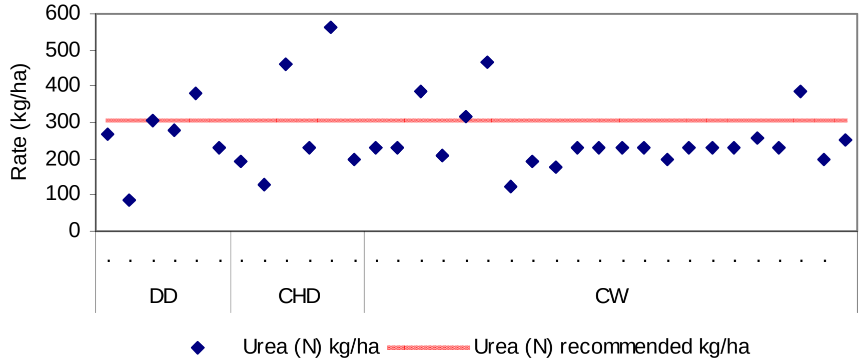
There is no significance difference ($P<0.05$) in average fertilizer use on wheat between wastewater farmers and clean water farmers (Table 4.7).

Table 4.7: Fertilizer use on wheat in wastewater and clean water areas

	Mean Average Fertilizer Use (kg/ha)		
Type	WW	CW	P
Urea (N)	277	246	0.74
MOP	44	82	0.64
TSP	113	95	0.34

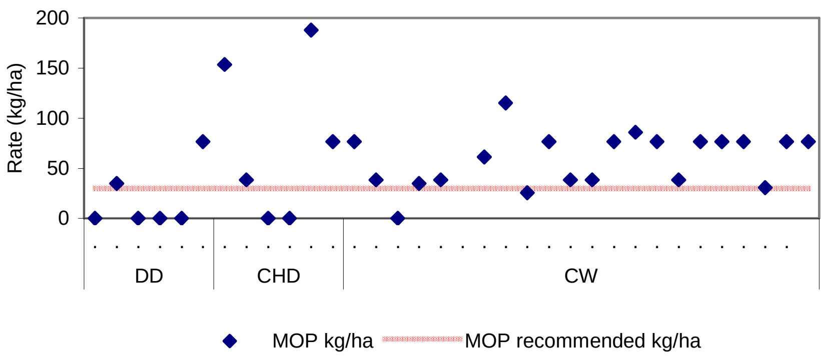
More detailed analysis of application rates of each fertilizer type suggests that CW famers are more consistent in their application of urea than wastewater farmers, usually applying just under the recommended amount; however this may relate to the larger number of wheat farmers in the CW area, which results in a larger sample for the analysis. The highest and lowest urea application rates were reported by wastewater farmers (Table 4.6).

Figure 4.6: Urea (N) application rates (kg/ha) and recommended levels for wheat



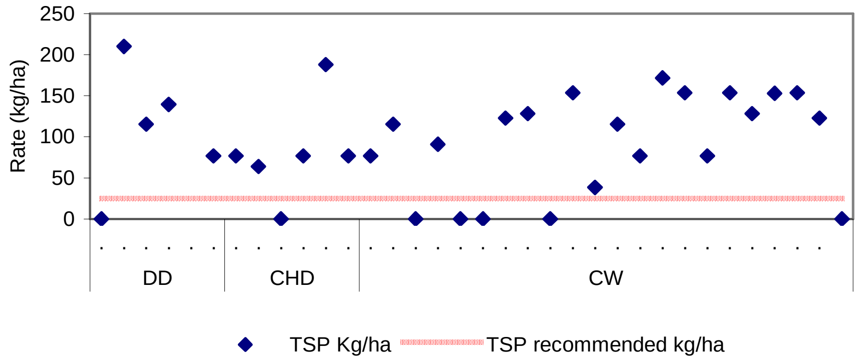
Application rates of MOP are interesting because they are generally above the recommended levels in all three areas, although no application is reported by four farmers in the DD area and two in the CHD area. The highest application rates are reported by two farmers in the CHD area (Table 4.7)

Figure 4.7: MOP application rates (kg/ha) and recommended levels for wheat



Similarly TSP application rates for wheat are consistently above the recommended levels but in this case there are five farmers in the CW area who do not apply TSP, as well as one in DD area and one in CHD (Table 4.8).

Table 4.8: TSP application rates (kg/ha) and recommended levels for wheat



Agrochemical Application, Pests and Diseases

The percentage of farmers applying pesticides to wheat is similar in both areas for insecticide and fungicide but application of weedicide in the ground water area is much higher (Table 4.9). This result is similar to that found for rice.

Table 4.9: Percentage of farmers who use agrochemicals

	Percentage of farmers	
Agro chemicals	**WW**	**CW**
Weedicide	0%	38%
Insecticide	40%	43%
Fungicide	7%	5%
Number of farmers in the sample answers	15	21

Farmers were also asked about pests and diseases in the area and most of the responses reveal that stem bore attack is very high with 53% of farmers in the clean water area and 47% in the wastewater area complaining about it.

Consumption

The pattern of consumption is similar to that for rice, with wastewater farmers consuming their entire yield. The price for wheat in the market was on average 15.5 Taka/kg in 2006.

Potatoes

Out of 129 sample farmers only 37 farmers (8 from DD area, 3 from CHD area and 26 from CW area) grow potatoes on around 10 ha of land. Comparison using univatiate analyses shows that there is a significant deference ($P<0.05$) between clean water and wastewater yield with the yield in the clean water area being almost 30% more than in the wastewater area (Table 4.10).

Table 4.10: Yield (kg/ha) difference between wastewater plots and clean water plots

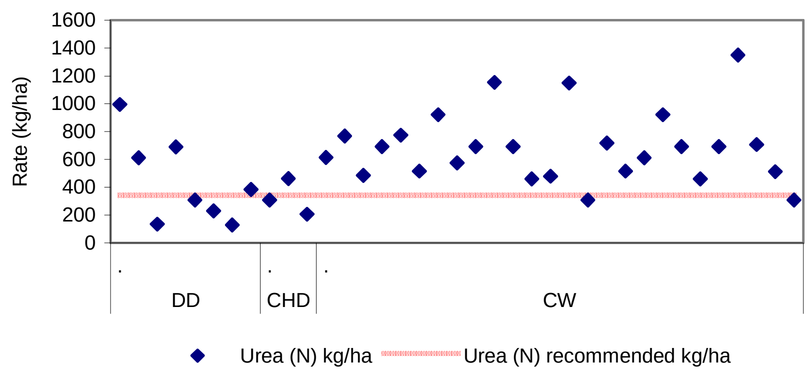
Type	Mean	Standard deviation	P<0.05
Clean water	20374	5783	0.01
Wastewater	14736	5991	

There is also a significance difference ($P<0.05$) between urea application in the wastewater and clean water areas (Table 4.11), with clean water farmers generally applying more urea than wastewater farmers and at rates above the recommendations (Figure 4.8).

Table 4.11: Fertilizer use in kg/ha in wastewater and clean water areas

Type		WW	CW	P
Urea (N)	Mean	403	680	0.005
MOP	Mean	208	296	0.238
TSP	Mean	290	296	0.902

Figure 4.8: Urea (N) application rates (kg/ha) and recommended levels for potatoes



Application rates for MOP and TSP are massively above the recommendations provided by DAE. The project is looking into why this is the case and is linking with the DAE to review the issue.

Figure 4.9: MOP application rates (kg/ha) and recommended levels for potatoes

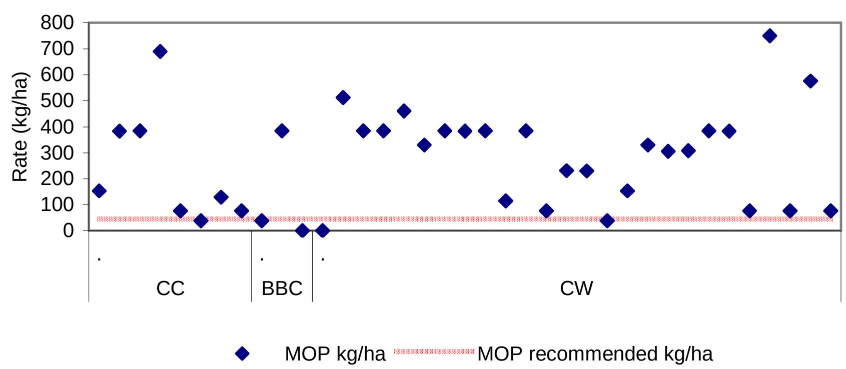
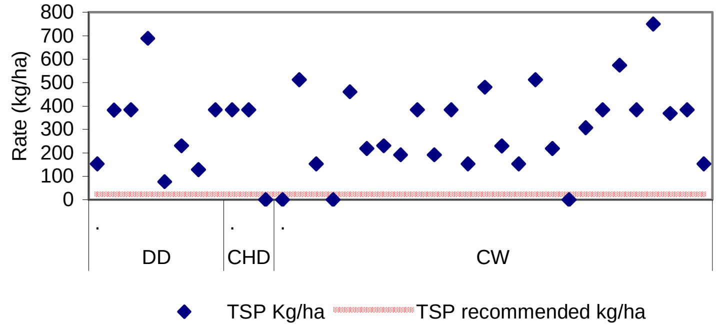


Figure 4.10: Current TSP application rates (kg/ha) and recommended levels



Indian Spinach, Spinach and Red Amaranths

Leafy vegetables are grown only in wastewater areas and yields are highly variable according to the yield data provided by farmers, with some yields being reasonably good but others being quite low (Table 4.12).

Table 4.12: Leafy vegetable yield

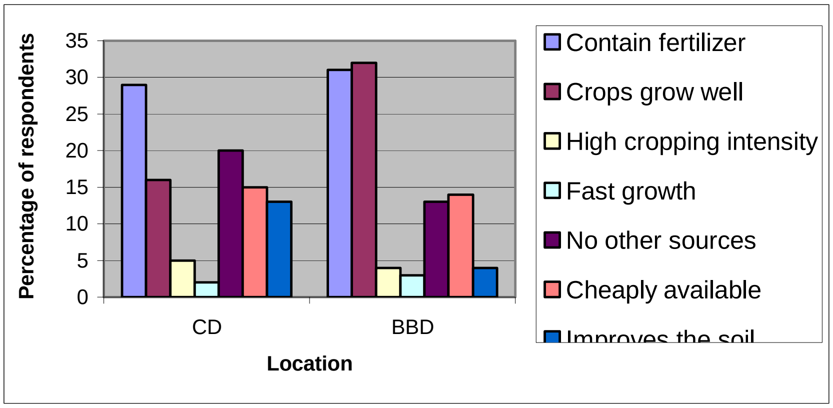
Crop	**Read Leaf (kg/ha)**	**Spinach (kg/ha)**	**Indian Spinach (kg/ha)**
Average	19357	23774	22999
Minimum	7560	12285	3685
Maximum	31500	30870	44100
Average production for the area	12000	36000	40000

Fertilizer use was found to be high but very variable with some farmers not applying certain fertilizers while others apply more than the recommended quantity (Annex I). As with the other crops no clear explanation was provided for this variation either by the farmers or by the DAE. The conclusion drawn by the research team was that the farmers do not have access to good guidance on fertilizer application. They therefore apply according to their perceived needs, resulting from years of experience or based on guidance provided by fertilizer dealers or other farmers.

5 Wastewater Issues

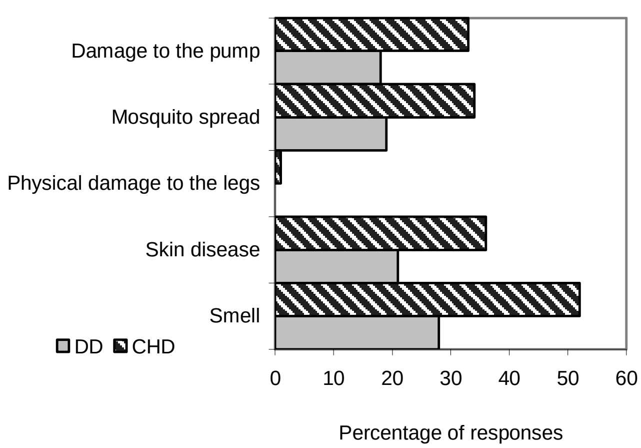
During the survey farmers were ask why they used wastewater and a few common points were identified and summarized (Figure 5.1). Most of the farmers said that they used wastewater because crops grow well and it contains fertilizer. They also used it because they did not have access to any other source of water but by using wastewater they had sufficient and did not have to practice any form of crop rotation based on water availability. Some farmers also commented that the availability of the water meant that it was possible to have a high cropping intensity.

Figure 5.1: Reasons for using wastewater water (percentage of responses)



During the transect walks and FGDs farmers identified problems that occured as a result of the presence or use of wastewater, these included smells, skin diseases, mosquito nuisance and damage to pumps. This last problem arises when solid waste in the drain is sucked into the pump; polythene bags are a particular nuisance. These findings were checked in the questionnaire and it was found that nearly a quarter of respondents faced several of these problems, with over 30% in both areas complaining about the smell. Very few farmers complained about physical injury from sharp objects (Figure 5.2).

Figure 5.2 Farmers' opinions on problems they face due to wastewater irrigation



The farmers were also asked if they perceived any particular problems with the water quality itself in terms of the waste that it carries. They were asked to say whether they felt that the water contained: oil and grease; solid waste; fecal matter; or harmful chemicals. They were also asked what impacts these particular things had on them and their livelihoods activities. As was expected it was not easy for the farmers to link specific pollutants with impacts. Almost all farmers said that they felt that the wastewater contained the first three pollutants. They felt that oil and grease interfered with agricultural production by coating the soil; as did solid waste because it blocked the pumps (Table 5.1).

Interestingly however they did not perceive high levels of harmful chemicals (Table 5.1). This is corroborated by the industrial survey that was undertaken, which revealed that there are a number of industries in the area, some of which are disposing of chemicals into the Dagapara Drain, but that none of these are large industries, nor are they using highly toxic or dangerous chemicals.

Table 5.1: Perceptions of farmers regarding water quality and its impacts

Perceived pollutant	Percentage of farmers in DD	Percentage of farmers in CHD	Perceived impact
Oil and Grease	93	85	Coating over soil Itching
Solid waste	96	92	Pump base blocked
Fecal matter	100	85	Smell Itching
Harmful chemicals	20	48	Skin disease Itching

Although they listed limited impacts on agriculture in this question, when they were asked more generally about how they believed wastewater affected the productivity of their land, most farmers said that it affected the vegetative phase of the crop and also that it increased the pest attacks. Some farmers (13%) also said that it reduced the yield. During the FGDs it was revealed that farmers tend to say that the wastewater affects the yield as they generally prefer the clean water over wastewater and try to emphasize the negative effects of wastewater.

6 Conclusions and Recommendations

There appear to be some differences in the crops grown in wastewater and non-wastewater areas with spinach and cabbage for example only being grown in the wastewater areas. This may be due to the difference in water availability in the two areas or perhaps the smaller plot sizes in the wastewater area, which is nearer the city where land is scarcer and more expensive.

The data on yields suggests that there is some difference between wastewater and clean water areas for rice and potatoes, with yields in clean water areas being higher, but this does not appear to be the case for wheat. The total production also tends to be higher in the clean water area because of the larger plot sizes, which means that these farmers have some excess that they can sell.

Fertilizer application rates are extremely variable and do not reflect either the guidelines provided by the DAE or the nutrients that are likely to be present in the wastewater. It is not clear why there is so much variation and gaining a better understanding of this will be a key part of the next stages of the work. It is possible that farmers are not aware of the recommendations or that they have chosen to ignore them based on experience. The results suggest that the identification of spatial changes of the nutrients in the incoming wastewater and their distribution over the fields could be extremely useful for better fertilizer management.

Pesticide applications do not follow a similar pattern either and needs to be investigated further. It would be expected that insect attack may be higher in the wastewater areas but insecticide application does not necessarily support this theory. Further discussions with farmers and DAE will be required to better understand the situation and to provide guidance.

The comments provided by farmers about wastewater were interesting because they highlighted the fact that farmers do not really like using wastewater but appreciate the benefits of its lack of scarcity. They also provided information about problems that could be addressed by the project such as the solid waste entering the drains and blocking pumps, and the problem of oil and grease.

References

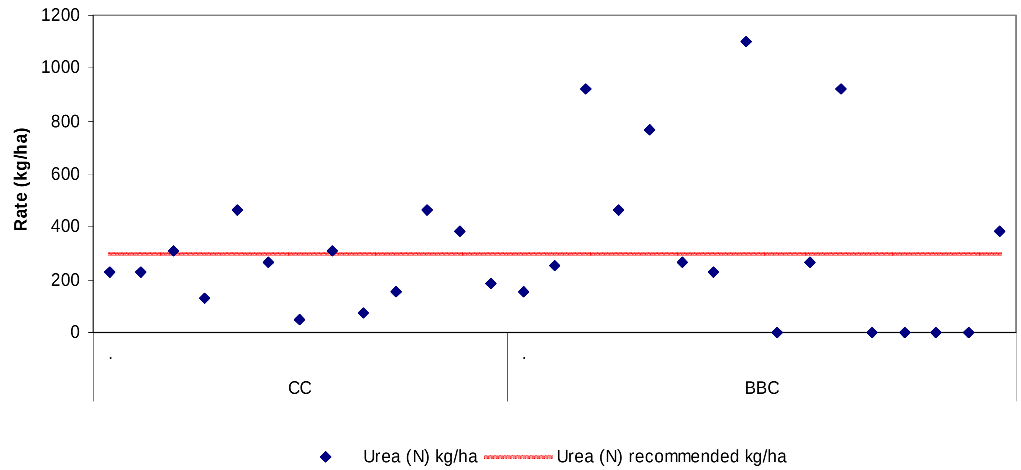
Ara, S., Akan, M. M. R., Amin, M. M. and A. Clemett. 2007. *Institutional Analysis for Wastewater Agriculture and Sanitation in Rajshahi, Bangladesh.* WASPA Asia Project Report 5. Colombo: IWMI.

Clemett, A., Amin, M. M., Ara, S. and M. M. R. Akan. 2006. *Background Information for Rajshahi City, Bangladesh.* WASPA Asia Project Report s. Colombo: IWMI.

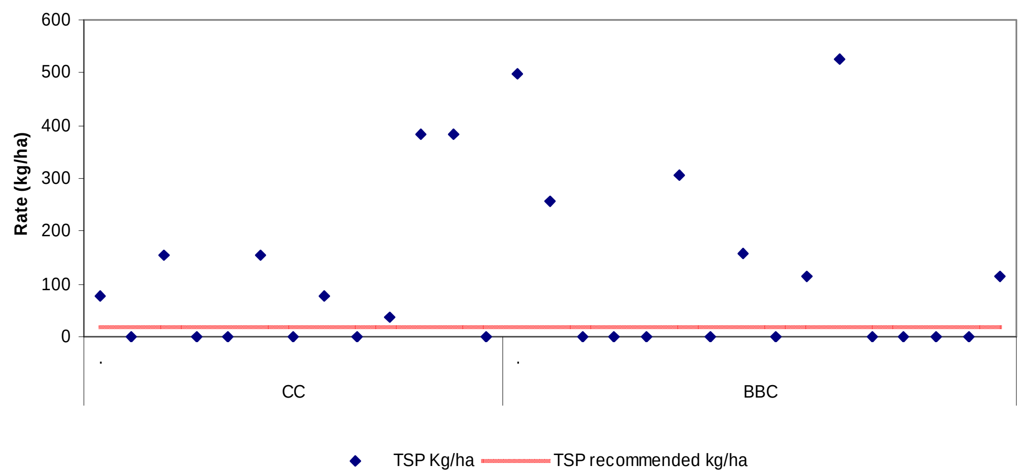
Annex I: Fertilizer application rates to vegetables

Key: CC = Dargapara Drain (DD)
BBC = Circuit House Drain (CHD)

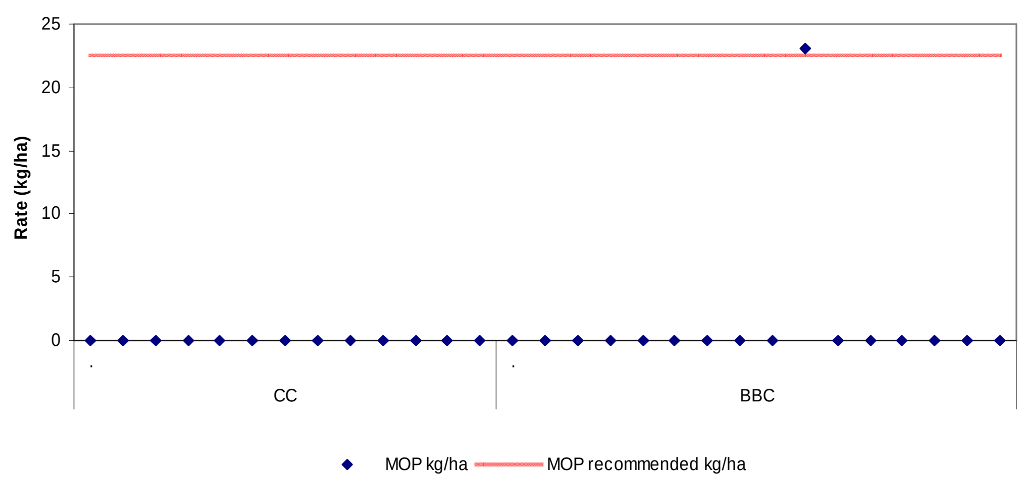
Urea application (Kg/ha) for red amaranths



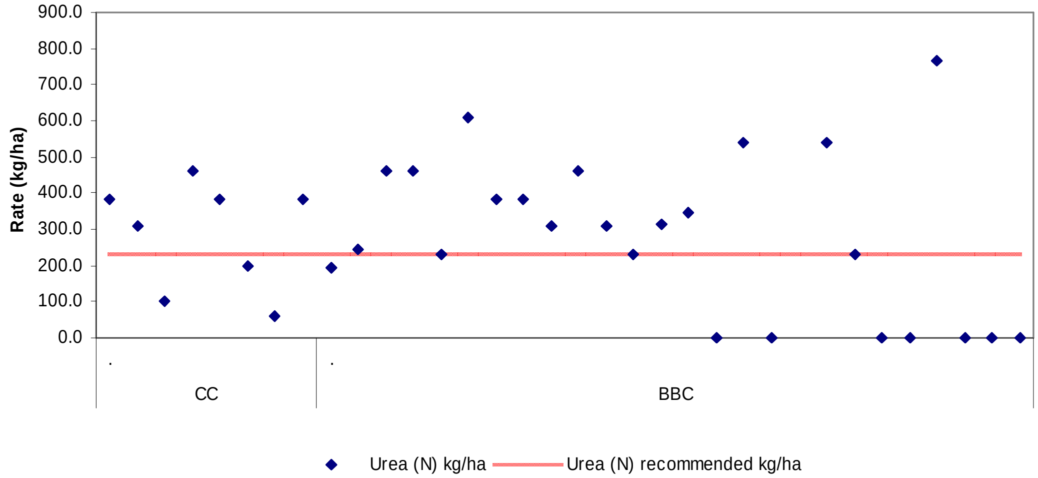
TSP application (kg/ha) for red amaranths



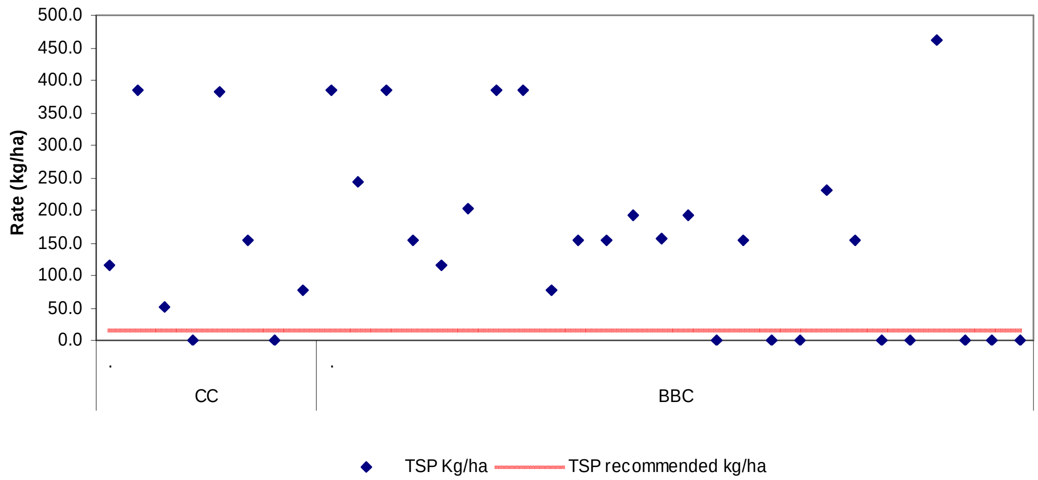
MP application (kg/ha) for red amaranths crop



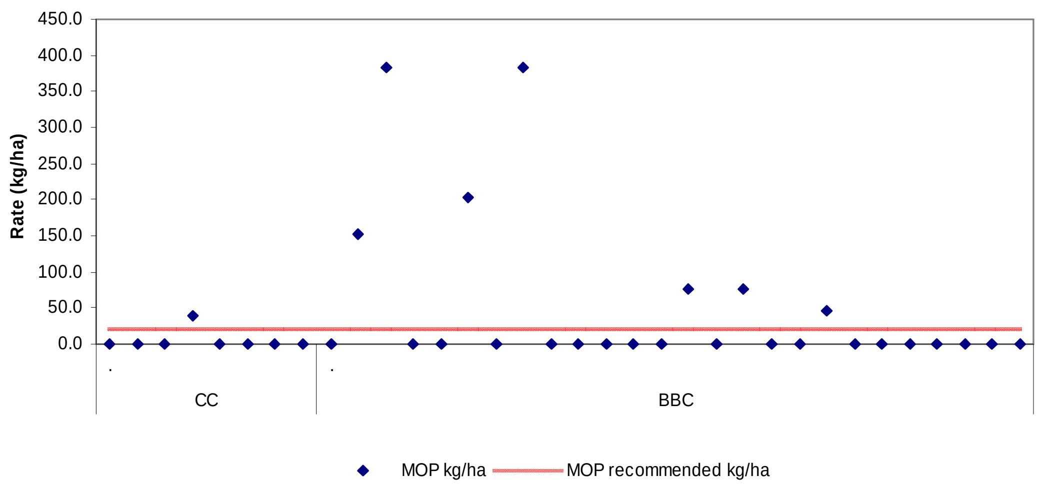
Urea application (kg/ha) for spinach crop



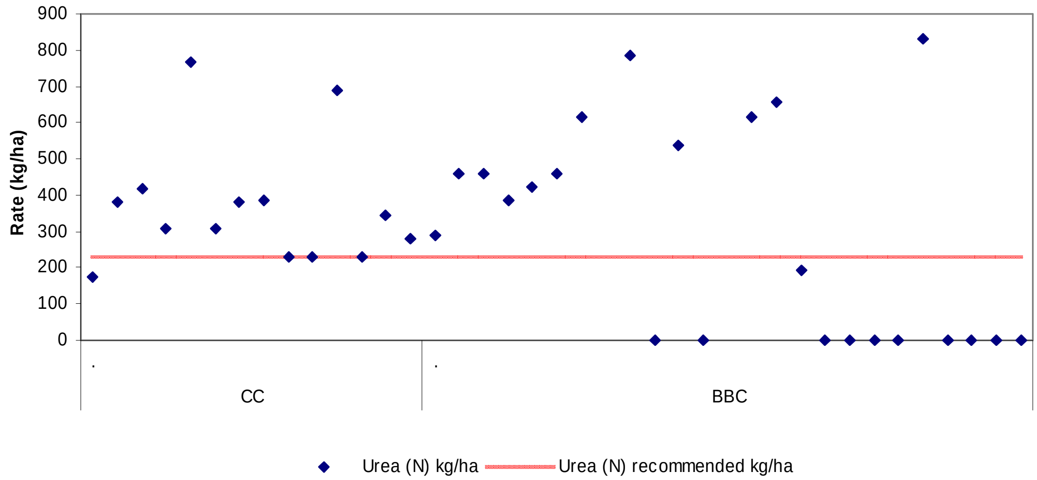
TSP application (kg/ha) for spinach crop



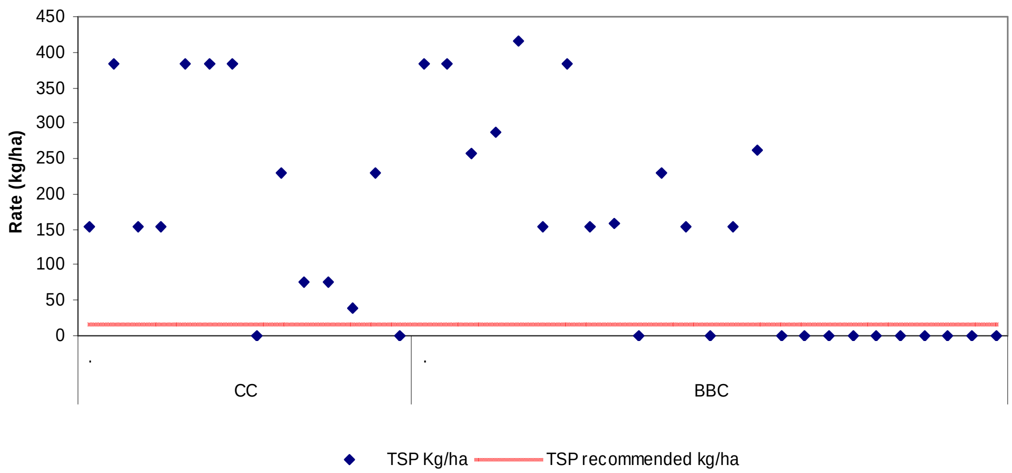
MP application (kg/ha) for spinach crop



Urea application (kg/ha) for Indian spinach crop



TSP application (kg/ha) for Indian spinach crop



MP application (kg/ha) for Indian spinach crop