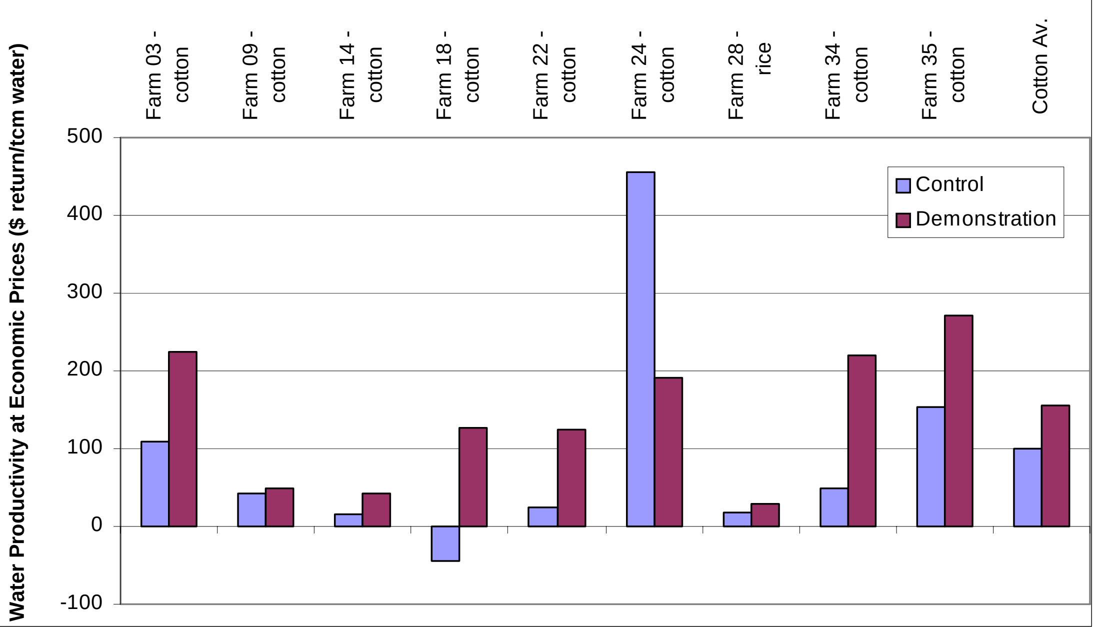
2 PRODUCTIVITY OF WATER

2.1 Index of Water Productivity

The farm summary tables shown in Annex D give a number of productivity indices for water and other inputs. As argued above, the most appropriate index of water productivity is economic gross margin as a return to water, in $/tcm. Figure 1 shows the values of this index for control and demonstration fields on sample farms.

Fig 1 Productivity of Irrigation Water in Sample Fields

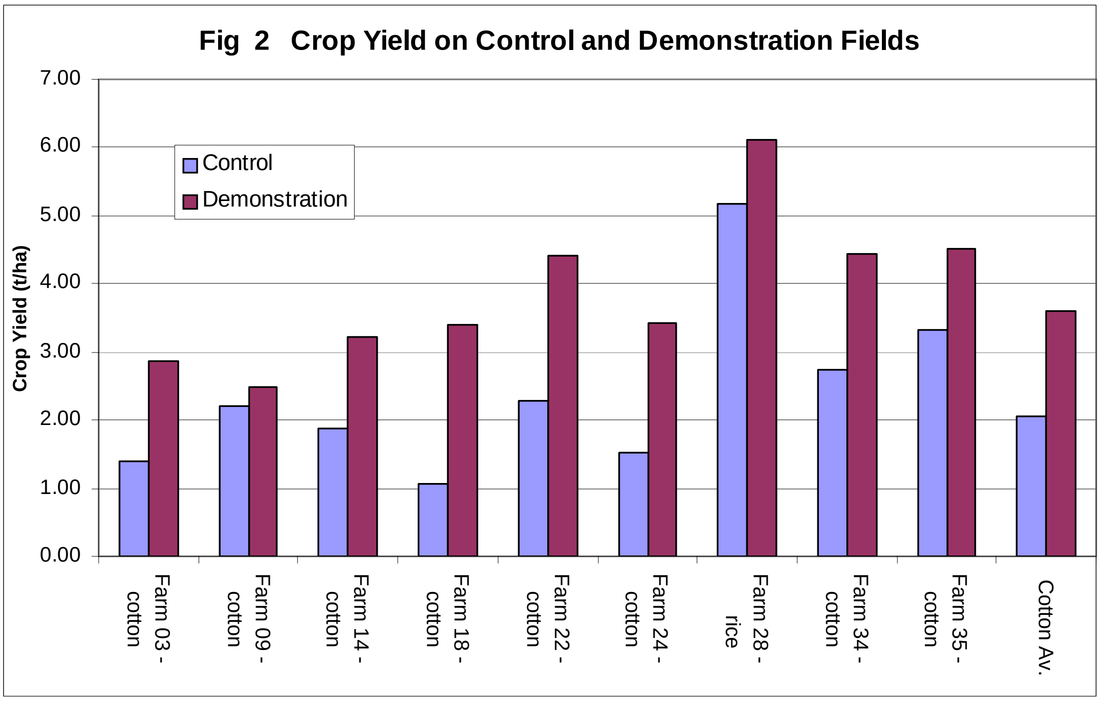


All fields, except the control field in Turkmenistan (which was late-planted), achieved positive values, and on all farms except Timur Malik (no 24) in Syrdariya, the value on the demonstration field exceeded that on the control field. The average for cotton demonstration fields of $156/tcm compared favourably with that on control fields of $101/tcm. The average improvement in water productivity over 8 farms with cotton was 152 percent.

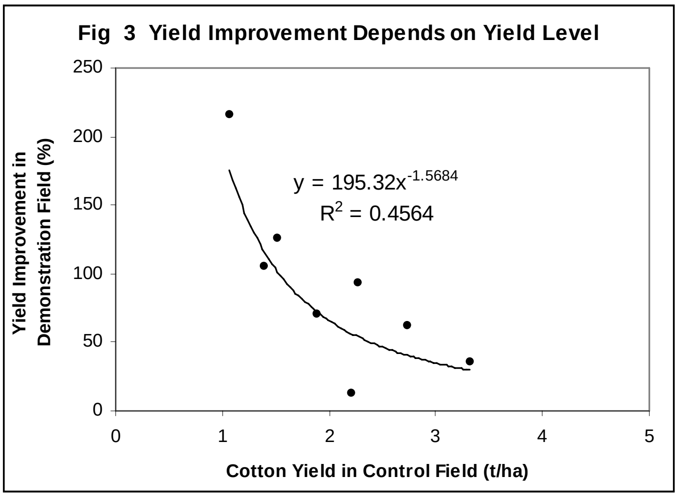
Farms Yakkatut (no 34) in Ferghana and Talashkan (no 22) in Surkhandariya achieved high improvements of 349 and 402 percent respectively, while the poorest performance was at Sadikov farm (no 09) in Kyrgizstan (where the cotton was also late planted and suffered exceptional cold) with only 16 percent. The control field at Timur Malik farm (no 24) was atypical, even for that area, in that it was semi-abandoned and was only irrigated once. With a high watertable supplying much of the crop need, the water productivity index was distorted. Excluding this abnormal result, **the average improvement in water productivity was 187 percent**, not too much below the overall target of 250 percent. The question arises if this result derived from yield increase, and hence gross margin increase, or from water saving, or from both together.

2.2 Crop Yields

Figure 2 shows the yields obtained in sample fields. Three farms achieved more than 4t/ha of cotton on demonstration fields and three farms more than 3t/ha, an excellent result. The average yield of cotton on eight control fields was 2.05t/ha, compared with 3.59t/ha on the corresponding demonstration fields, an overall average improvement of 91 percent. This achievement far exceeded the target of 75 percent in the terms of reference. Both rice fields yielded exceptionally well with the demonstration field exceeding 6t/ha of paddy but with a yield improvement of only 18 percent over the control.

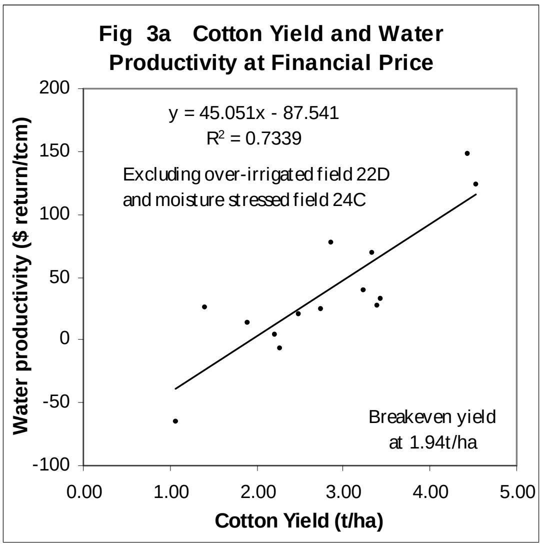


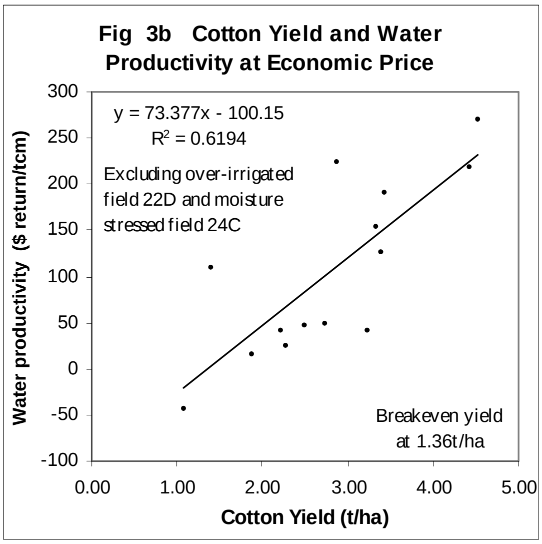
As expected, the absolute yield level in the control field limited the magnitude of improvement: the higher the yield, the smaller is the scope to improve it. This is illustrated in Figure 3. The odd point is farm 09 where late planting of the demonstration field and cold early summer weather limited the possible improvement. Excluding this point, the R^2 value increases to 0.86 and the extrapolated fitted curve intersects the X-axis at about 5t/ha of cotton. This would seem to set the upper limit on the potential to improve yield of the current cultivars of cotton, and is in keeping with expectation.



The question arises as to what the managers did on the demonstration fields that so markedly improved the yield. This is discussed in Section 3 below.

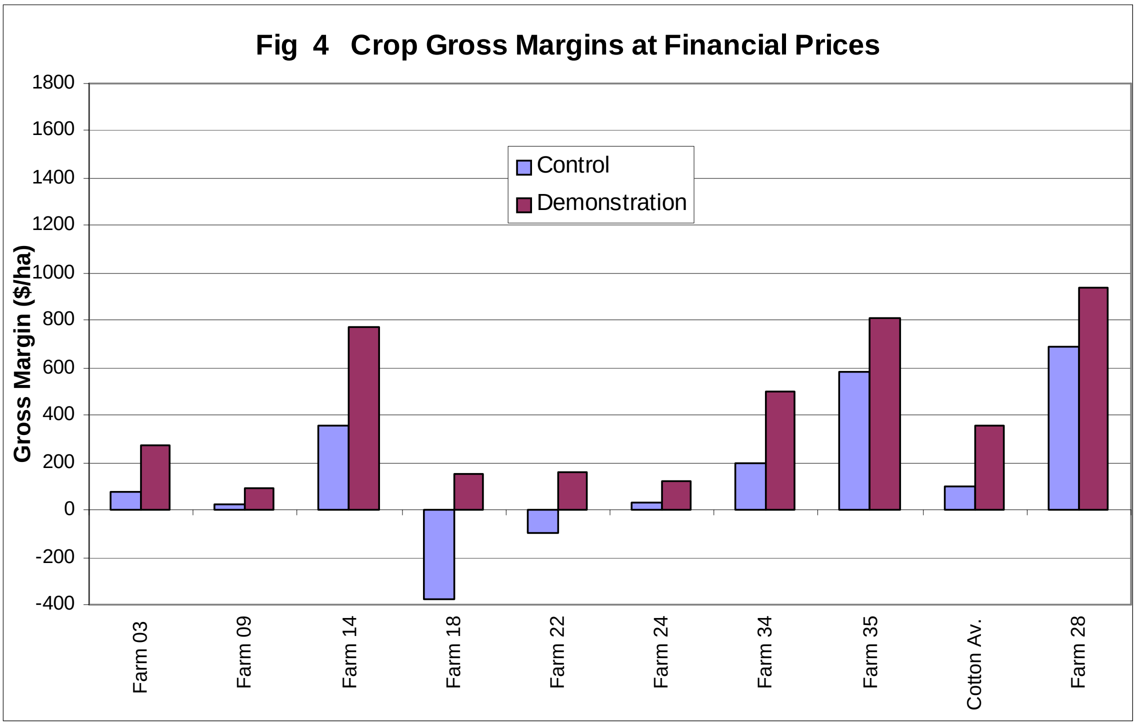
Due to the influence of crop yield on the water productivity index, the expected close relationship between them is evident in Figures 3a and 3b for financial and economic prices, both linear equations being highly significant with P = 0.01. It is not “profitable” to irrigate where the water productivity is negative and from the above figures, the breakeven yield is 1.94t/ha of cotton at financial prices but as low as 1.36t/ha at economic prices. Areas of the Golodneya Steppe are no longer yielding above 1.94t/ha of cotton and so irrigation water is being used under unfavourable conditions.





2.3 Crop Gross Margins

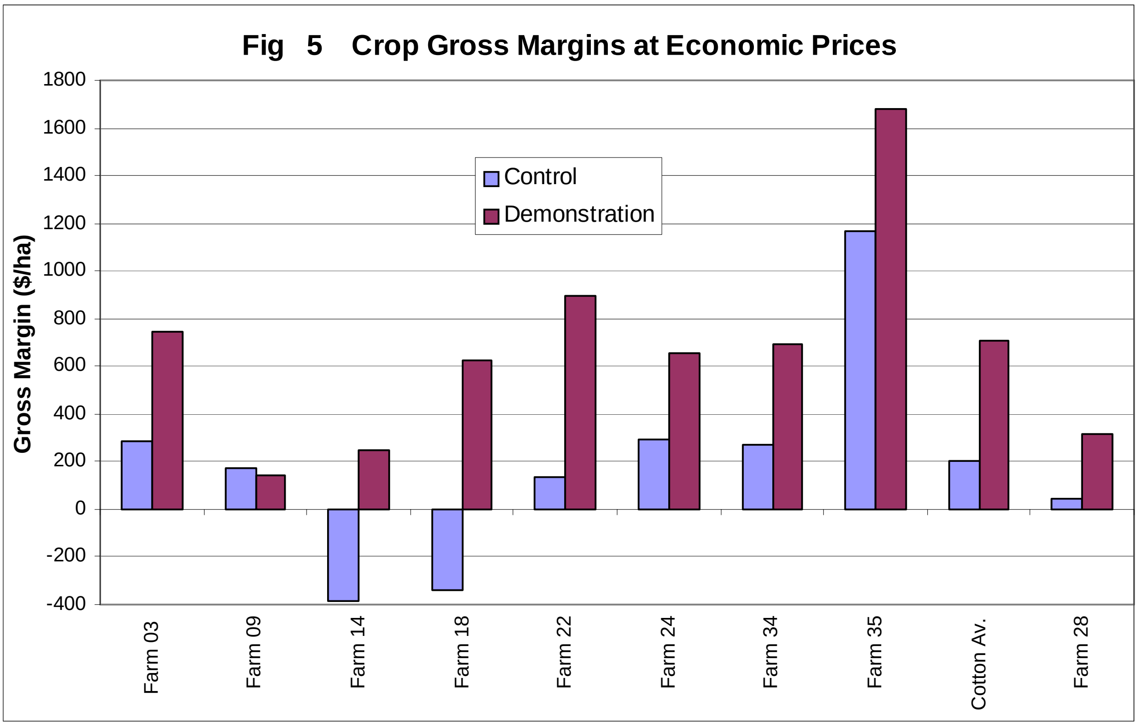
Figures 4 and 5 show the crop gross margins in $/ha at financial and economic prices respectively. The full crop budgets with details of inputs and from which gross margins are calculated are given in Annex E.



At financial prices, the gross margin on the demonstration fields averaged 198 percent improvement over the control fields, indicating that the improvement was a combination of increased yield and better use of resources. The best return at financial prices came from the rice demonstration field, $936/ha.

The large financial benefit from rice derives from a combination of high yield and high price. The control field on farm 35 (Bukhara) was relatively well managed and contributed almost $600/ha at financial prices to the farm budget. Financial gross margins on the demonstration fields were somewhat more attractive on all farms, with those on farms 14 (Tadjikistan) and 35 (Bukhara) contributing around $800/ha, the former on account of high price, the latter due to high yield. Two fields of cotton made a loss: control fields on farms 18 (Turkmenistan) and 22 (Surkhandariya). However, financial return on the control fields of farms 03, 09 and

24 were small and would contribute little to paying for the large overhead costs of the farm. Even the demonstration fields on four farms failed to make $200/ha, indicating that more attention should be given to producing high yield at much reduced costs of production.



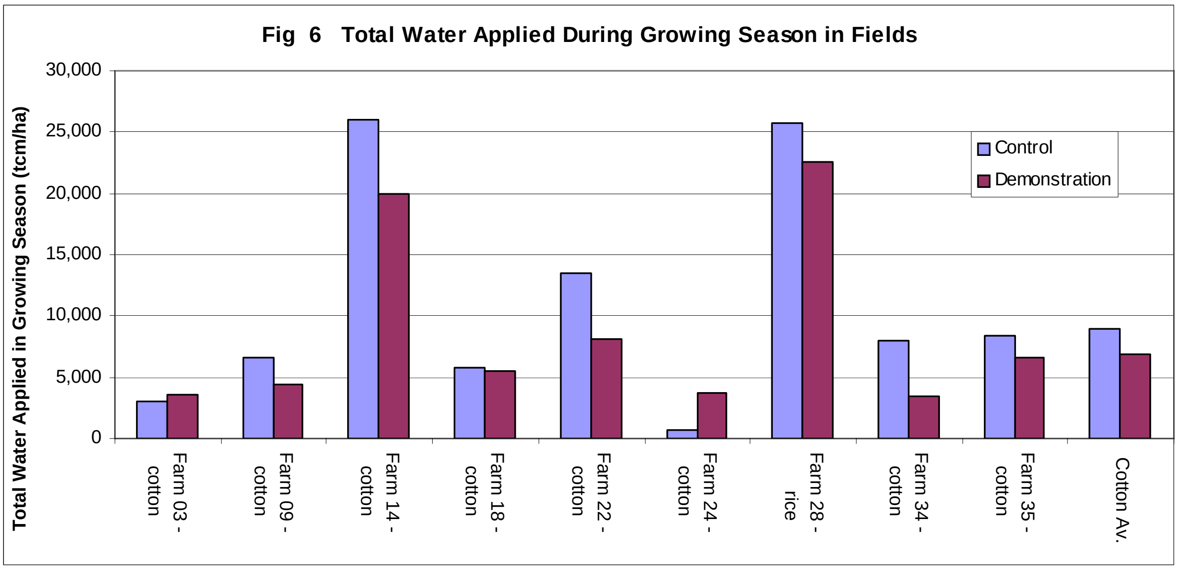
The use of economic prices on the whole increases crop gross margins, mainly on account of the better farm gate price for cotton, but with two exceptions. The much greater use of more expensive water at economic price and because the financial price of cotton is close to the economic equivalent markedly reduced the gross margins on farm 14 (Tadjikistan). The economic return to rice also is markedly less due to the high cost of water and no price benefit. The import parity price of rice is believed to be less than the local market price due to quality preference. Otherwise, gross margins at economic prices on cotton demonstration fields were markedly better than those on the control plots due to greater revenue. The economic return of cotton at farm 35 (Bukhara) was particularly impressive at $1680/ha, due to a combination of high yield and low variable costs indicating the potential for cotton production in Central Asia.

2.4 Water Use

Data on water use are summarised in Annex D.

The total water applied to the crops in the vegetative period is illustrated in Figure 6: in a few cases, the total includes a pre-irrigation shortly before planting when the reason given was for irrigation and not for leaching. The cotton farms on average used 39 percent more water on the demonstration than the control fields but the atypical control field of farm 24 distorts the average. If this farm is excluded, the cotton demonstration fields used **30 percent less water** and the rice demonstration 12 percent less than the control. Two farms used excessive amounts of water, greater than 20tcm/ha: farm 14 in Tadjikistan for cotton, and farm 28 in Karakalpakia for rice.

Much water was used to irrigate the cotton on farm 14 (Tadjikistan), 26tcm/ha on the control field and 20tcm/ha on the demonstration field. On account of steep slopes and gravely soils, there is a tradition in the area of massive over application of water in order to satisfy the crop need. In the case of the demonstration field, located on the lower slopes of the piedmont, the soil texture is not very light and nor is the infiltration rate rapid. With subdivision of the whole furrow into five sections in order to make it possible to irrigate with greater efficiency, the quantity of water applied was unjustified. The mitigating circumstance was the death in mid-season of the Supervisor and that, with communication difficult; it was not possible to train the replacement Supervisor in time. Water on this farm is economically expensive, as at the end of the Big Ferghana Canal there is little summer flow and much of the water is pumped up from Lake Kairak Kum.



The heavy consumption of water for rice production has been referred to in several previous reports of WARMAP. The reason is the poorly controlled overflow from basins in maintaining water level, and the high deep percolation loss due to the low content of clay in most soils used for rice and that the surface is not normally “puddled” before sowing.

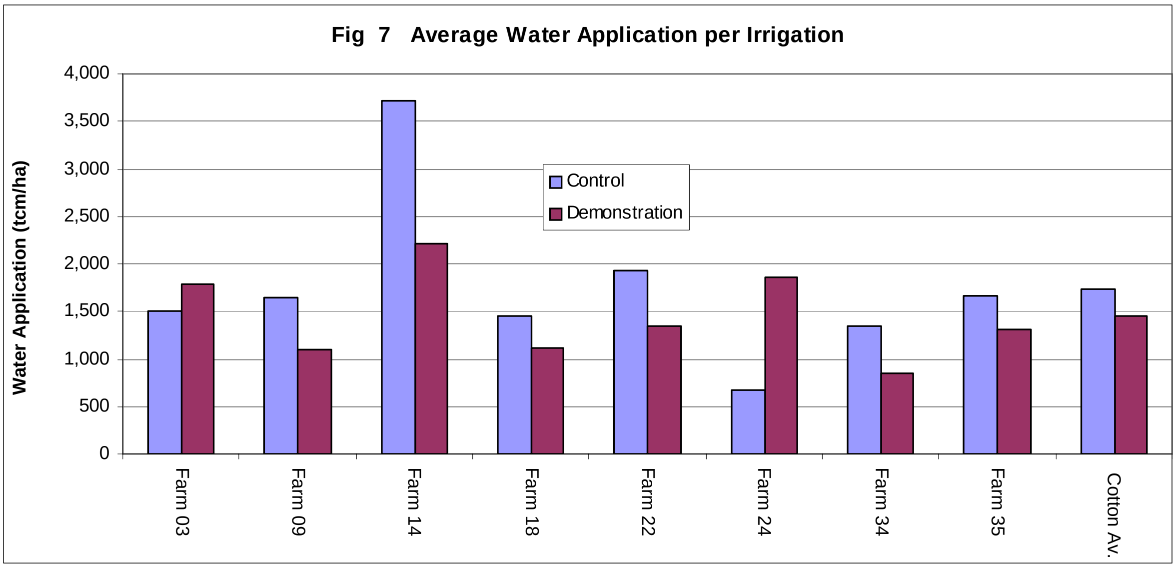
The general average for cotton was close to the estimated average water loss by evapotranspiration, of about 6-7tcm/ha but this should not be taken to imply high irrigation efficiency. Cotton generally is irrigated on average three to four times, yet rather more frequently on these selected WUFMAS fields. Without taking account of the groundwater contribution, scheduling by CROPWAT (FAO, 1998) indicates a need for about eight irrigations. Paradoxically, more frequent irrigation, without improvement in efficiency, would increase demand for water. Indeed, in most lands, it is the groundwater that makes up for the potential deficit from the too-long irrigation intervals. The presence of the high watertable in most lands is the consequence of mismanagement of water in the canals and fields, with surplus discharging to the watertable. Sub-surface irrigation is a costly process so that the considerable groundwater contribution should not be seen as a virtue. Improved water management with less discharge to the groundwater, if widely practised, would inevitably lead to fall in the watertable. The benefits would be in the lower use and cost of water and drainage, less salinity and improved yield. The drawback would be the need for and cost of more frequent irrigation.

Seasonal patterns of groundwater contribution were estimated using the modified Laktaev model (WUFMAS Annual Report for 1997), as illustrated in Figure 9.

2.5 Irrigation Schedules

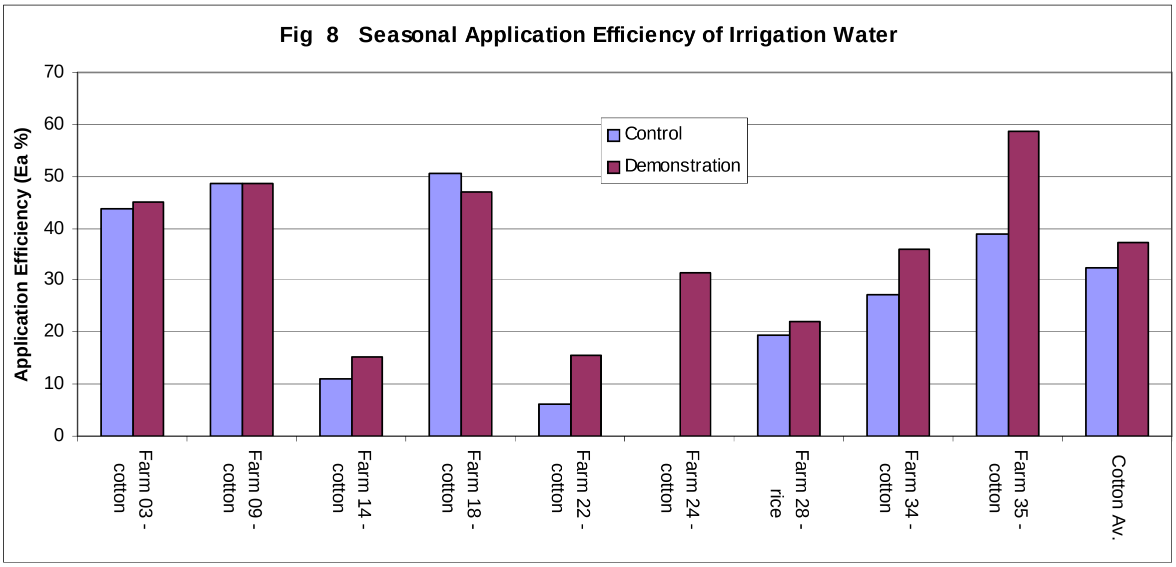
On average, the two fields were irrigated with equal frequency, so there was no marked change in schedules. Irrigation scheduling of the demonstration fields was based on the system of daily water balance introduced by WUFMAS in 1996. This system is cheaper and more flexible than the system formally used by the Ministry of Water Resources in Uzbekistan called Irrigation Scheduling System (ISS) and gives responsibility to farm staff. The small meteorological station, with USDA Class A evaporimeter and rain gauge established on each farm, is illustrated in the photograph section. Daily estimates of ETo are calculated from the pan evaporation by the farm assistant on form 35, and transferred to form 36 where the daily water balance is calculated for the field. The readily available moisture in the rootzone based on the one-off laboratory estimation of the soil’s AWC, maximum after rain or irrigation, is gradually consumed by evapotranspiration until exhausted, on which day the field should be irrigated. This is illustrated in Figure 10.

Figure 7 shows the average gross water application for each irrigation of cotton during the season, control fields averaging 1.74tcm/ha and demonstration fields 1.45tcm/ha.



2.6 Irrigation Efficiency

Application efficiency (E_a%) is the main indicator of the standard of water management. It is most meaningfully measured by the seasonal net requirement divided by the seasonal actual water use. Estimates are shown in Figure 8. This method takes no account of reuse of water and as such is an economic rather than a hydraulic index. When a field is under-irrigated, water is saved but yield is lost, and the estimate of E_a is inflated, in some cases >100 percent. This occurred in several fields, normally in late July and August when water demand was at its greatest. The average values shown in this report are based on irrigations that individually did not exceed a theoretical maximum of 75 percent. However, this is a rather arbitrary limit in view of far lower maximum E_a values estimated by PUMA (see report in Annex B), and as such, it is highly likely that average values shown in Figure 8 are over-estimated.



The seasonal average E_a averaged 32 percent on control fields and 37 percent on demonstration fields (or 38 percent excluding farm 24). This represents **a 43 percent improvement** by the WUFMAS field staff in the management of water during irrigation. Considering the prognosis made in the July report (Annex B), and in particular the difficulties imposed by the too late start in the season and the failure to be able to address the main constraints of water supply, land level and compacted sub-soil, this is an impressive result.

Fig 9 Groundwater Depth and Daily Water Contribution to Rootzone
Farm 18, Field 09 Demonstration

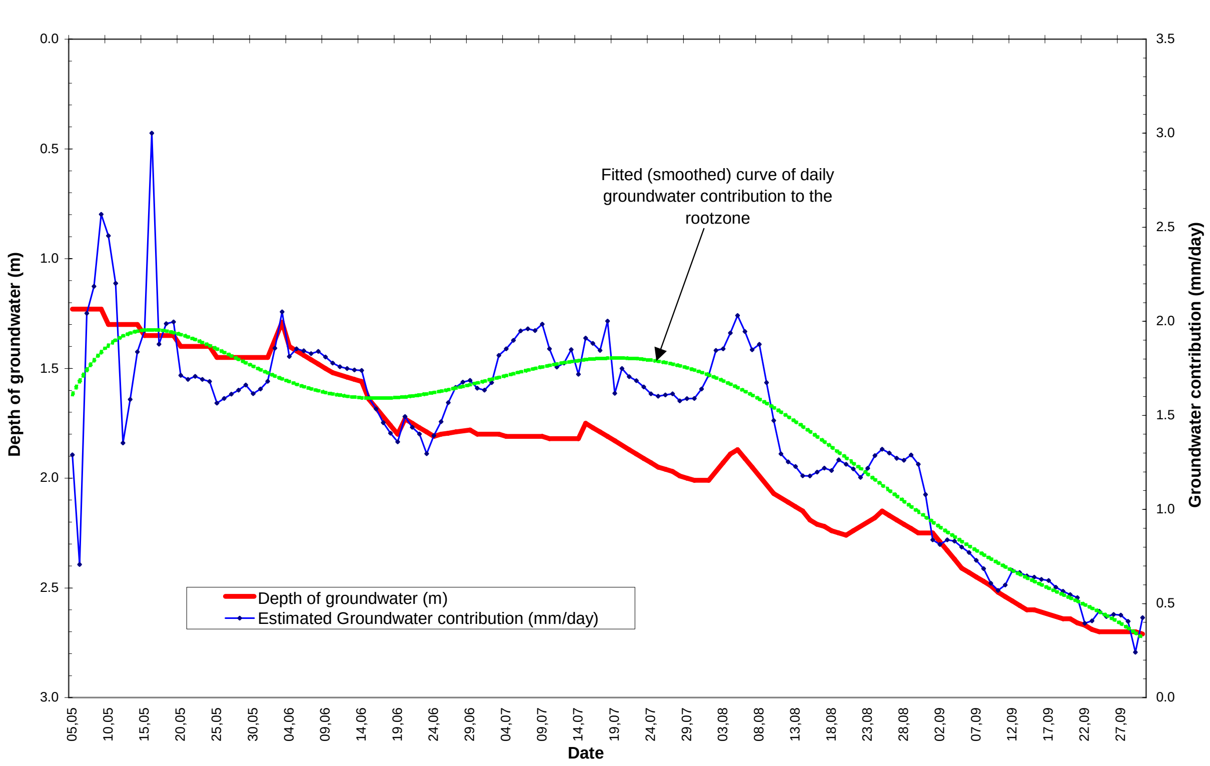
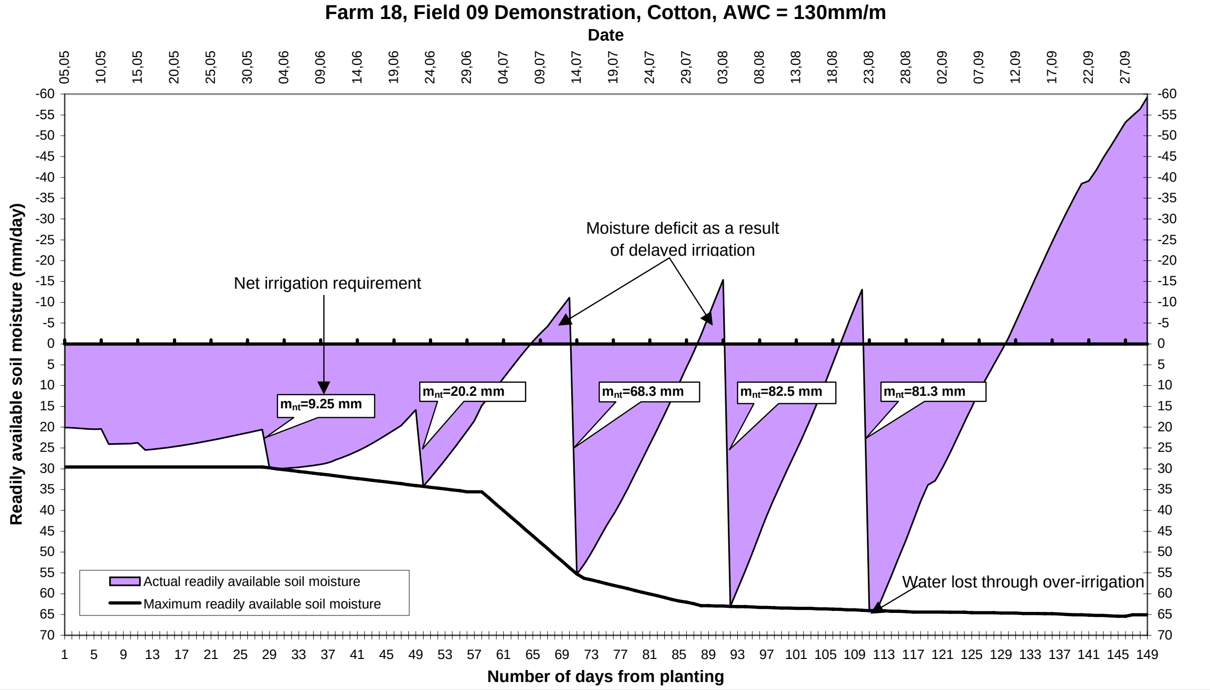
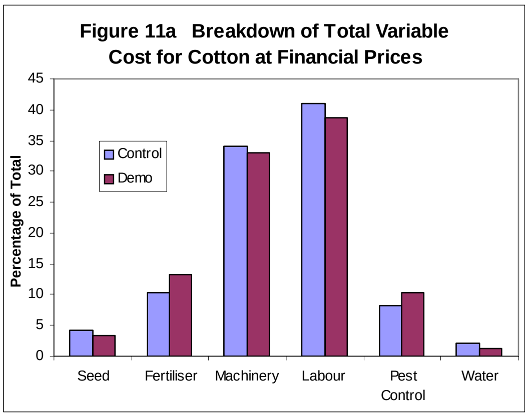


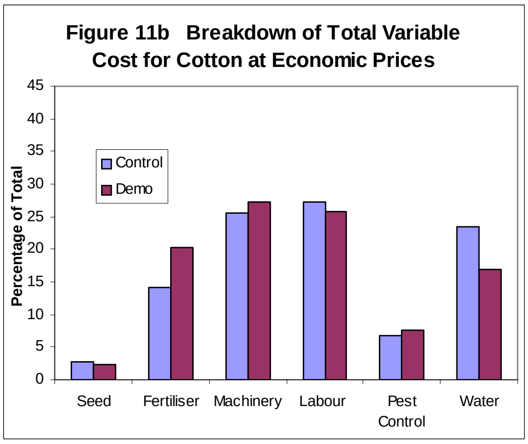
Fig 10 Irrigation Schedule and Seasonal Pattern of Readily Available Soil Moisture in Rootzone
Farm 18, Field 09 Demonstration, Cotton, AWC = 130mm/m



2.7 Return to Water Compared With Other Inputs

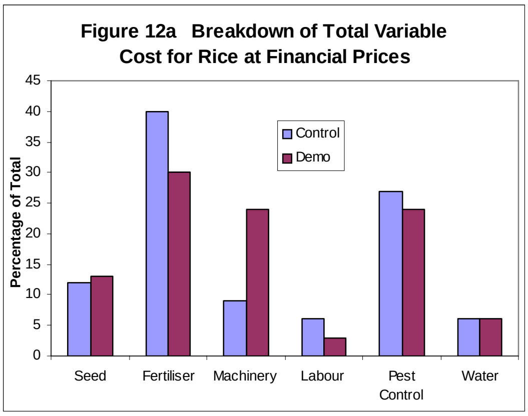
Figures 11a and 11b illustrate the comparative expenditure on different inputs for cotton in terms of the average percentage breakdown of the total variable cost, at financial and economic prices respectively. The patterns are similar, apart from the much greater proportional cost of water at economic prices. There is substantial variation between farms, for example the proportion spent on labour varying from 77 percent in Kyrgizstan (no. 09) where labour is plentiful to 17 percent on farm 24 in Syrdariya where labour is scarce.

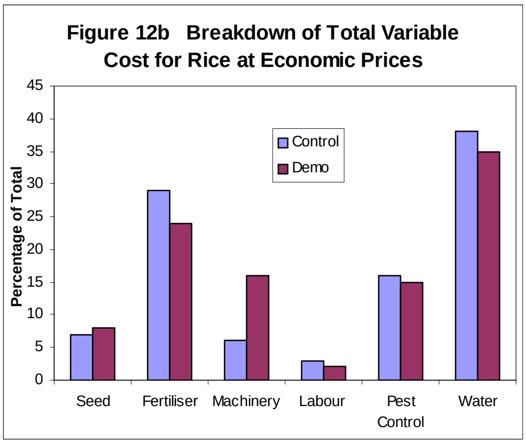




The relatively high cost of labour reflects the use of a standard wage rate of $2 per day for all farms. This is largely an imputed price and may under-estimate the real but hidden financial cost of labour. Labourers on state farms, together with other local families, traditionally receive free access to land for private use, a share of farm produce such as wheat, lucerne, fruit, straw and cotton stalks, and provision of free housing, domestic water, gas, electricity, schooling and medical facilities. Families allocated "private" plots still receive most of these benefits without charge.

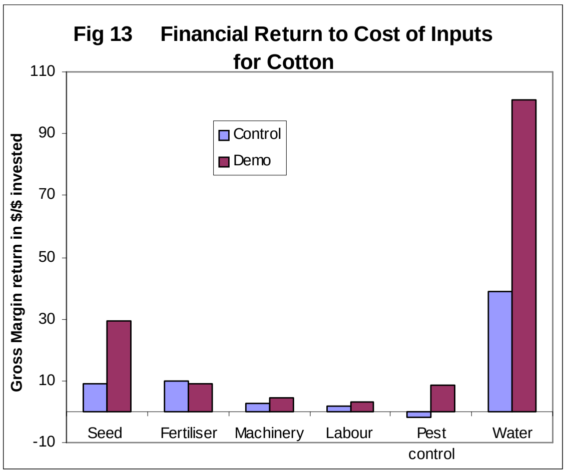
The pattern for rice is quite different to that for cotton as shown in Tables 12a and 12b for Farm 28. The heavy use of fertiliser and small labour cost are apparent, and the impact of the heavy use of water is clear when economic prices are used.

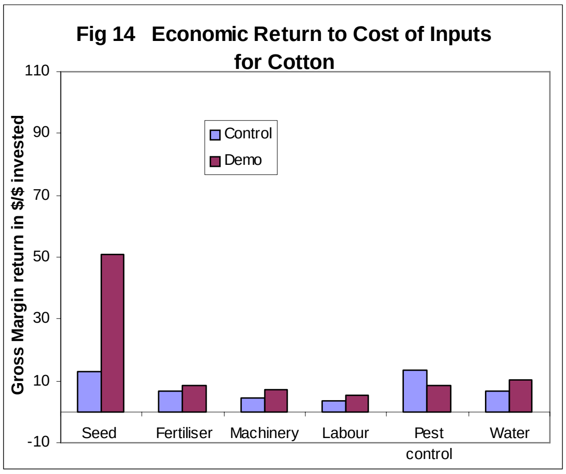




As explained in the Introduction, the best index for comparisons between the factors of production that compete for scarce investment capital, is the gross margin return to investment. The average returns for cotton are shown in Figures 13 and 14 for financial and economic prices respectively. All returns with the exception of pest control in cotton on the control fields were positive. In percentage terms, most investments yielded far higher than international interest rates on short-term capital.

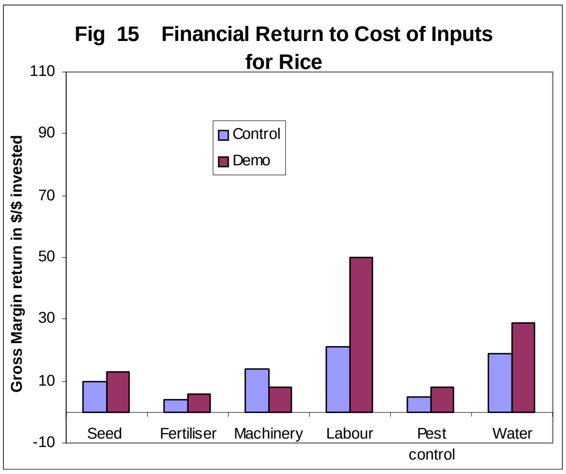
The most obvious feature of these figures is that at current financial prices, cotton's return to water far exceeds that of other factors. The additional benefit on the control fields of greater yield and reduced water greatly improved this productivity index of water. In fact, at financial prices the greater use of all factors of production in the demonstration fields, except fertiliser, increased the productivity index compared with the control fields. However, the benefit was very small, with the exception of seed, and is more the consequence of greater yield than a real response to the factor.

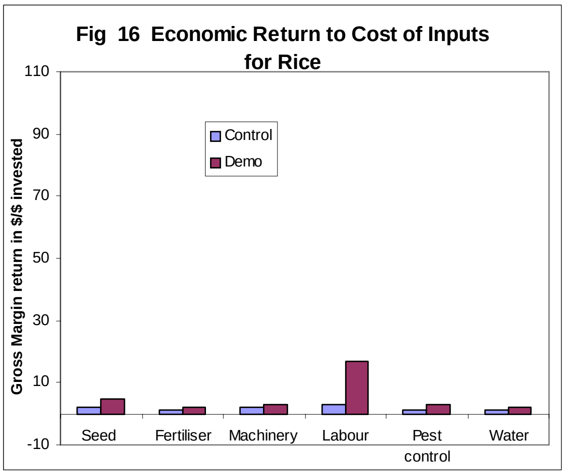




At economic prices, the pattern is more stable with much the same return to investment on all factors of production excepting seed cost, suggesting that the pattern of investment is balanced. It would seem that the budget for cotton would tolerate greater investment in seed if this could be justified in terms of return, but otherwise, there is no evidence that the extra investments on the demonstration fields compared with the control fields had more than a marginal impact on profitability.

The conclusions for rice are much the same as for cotton as illustrated in Figures 15 and 16. The small use of labour in rice production reflects in a more pronounced return, particularly on the demonstration field. It should be noted that in the WUFMAS accounting procedure, the cost of labour directly associated with machinery is included in the operating cost of the machines and only casual extra labour is recorded separately as shown in these figures.





The conclusion from this analysis is that water is currently far under-priced at financial prices and raising the price to the economic level would seem to be a rational step. In this analysis, the financial price of water is mostly below $1/tcm, and free in Turkmenistan, but an economic price of $15/tcm is used for gravity fed water, and $30/tcm for pumped water to the farm in Tadjikistan. In this event, farmers would need to reallocate their resources, spending less on expensive items such as heavy use of machinery and fertiliser in order to pay the extra cost of water.