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EFFECT OF ENHANCED WATER ALLOWANCE ON THE PERFORMANCE OF TILE DRAINAGE SYSTEM AT SHAHBAZ GHARI PILOT PROJECT AREA OF SWABI SCARP

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ABSTRACT
Field study was conducted at Shahbaz Ghari Pilot Project Area of Swabi SCARP to evaluate the effect of enhanced water allowance on the performance of tile drainage system, from August to December, 2002. Average water table depth from 17 observation wells at site 1-A and 25 at 1-C was recorded weekly. For the determination of drainage coefficient, laterals discharge was noted from 7 laterals at site 1-A and 2 laterals at site 1-C on weekly basis. To determine EC and pH, soil samples were collected from the root-zone at head, middle and tail of the research area; water samples were collected from all laterals at both site. The cropping pattern and yield of the major crops before and after increase in water allowance were assessed through farmers' interviews. Average water table depth from the ground surface at site 1-A ranged from 0.54 to 1.34 m and at 1-C it ranged from 0.75 to 1.45 m during the study period. Actual drainage coefficient at site 1-A ranged from 1.36 to 2.51 mm/day whereas at site 1-C it ranged from 0.24 to 1.09 mm/day. Average electrical conductivity of soil at site 1-A was 0.84 dS/m. EC of drainage outflow of site 1-A and 1-C was 0.93 and 0.76 dS/m, respectively. The pH values of the soil and drainage water of both sites were alkaline (8.10-8.58). There was no significant change in cropping pattern but yields of sugarcane, rice and wheat were increased by 16, 24 and 37%, respectively, after the increase in the water allowance. According to the farmers, salinity and water logging problems have significantly declined after the increase in water allowance. It can be concluded from results that after increase in water allowance the singular tile drainage system of Shahbaz Ghari Pilot Project area is working well.

Keywords: Water Allowance, Drainage System, Swabi Scarp

INTRODUCTION
Poor management on irrigated agriculture results in water logging and salinity problems. The percolating water raises the water table which reaches the surface, suffocates the roots and after evaporation deposits salts on surface, thus causing water logging and salinity. A significant portion of the irrigated land in Pakistan has been affected by water logging and soil salinity and it is feared that many areas might get converted into wet desert. Water logging and salinity have caused threat to crop production, and natural environment in the country. Pakistan is an agricultural country and about 70% of its population earns their living from this sector. Therefore, Government of Pakistan has assigned high priority to the control of water logging and salinity. To cope with the problem, the Government of Pakistan started the Salinity Control and Reclamation Project (SCARP), in different parts of the country. The main objectives of the SCARP project were: to lower the water table; to reclaim saline soil; and to provide full management of groundwater resources (Qamar, 1990).

Water table fluctuation occurs in different season and it causes the plant roots to rot off. In the rainy season when water table rises it fills the soil pores, not only displaces the air in the soil but also obstructs the gases, which are given off by the roots. Low and high water table affect yield (Kandil and Willardson, 1992). Lu (1994) reported that water logging lower the rate of photosynthesis, transpiration and stomatal conductance. So drainage of agriculture land is necessary to provide a suitable environment for plant and to increase production and sustain yields over a long period of time. Bhutta *et al.* (1996) presented a report which shows that pipe drainage are generally capable of controlling water table between the pipelines at depth of 1.0 to 1.5 meter below the natural surface. Bengston *et al.* (1995) compared the surface and subsurface drainage and observed that subsurface drainage was more effective than the surface drainage.

Salinity problems encountered in irrigated agriculture are frequently associated with an uncontrolled water table within one to two meters of the ground surface. In most soils with shallow water table contains salts, it becomes a continual source of salts to the root zone as water is used by the crop or evaporates at the soil surface. Salinization from this source can be rapid in irrigated areas in hot climates where portions of the land remain fallow for extended periods. The rate of soil salinity accumulation from an uncontrolled shallow water table will depend upon irrigation management, salt concentration, depth of the groundwater, soil type and climate conditions. Mian and Mirza (1993) reported that out of the salt affected soils of NWFP 63500 acres are porous saline-sodic soils, 2200 are dense saline-sodic soils and 12800 acres are soils with surface/patchy salinity and sodicity. Shallhevet (1994) reported that most crops were more sensitive to the effect of salinity during the seedling stage. In arid and semi arid climates, a salinity problem caused or complicated by poor

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drainage can not be adequately controlled until the water table is stabilized and maintained at a safe depth usually at least two meters. This requires open or tile drains or drainage wells to remove a part of the salty subsurface water. Effective salinity control, therefore, must include adequate drainage to control and stabilized the water table and leaching to reduce the accumulated salts.

After the installation of tile drains in Swabi SCARP, the irrigation water allowance of the area was enhanced from 4 cusecs per 1000 acres to 9 cusecs per 1000 acres. The research work was conducted at Shahbazi Ghari pilot project area of Swabi SCARP to study the impact of enhanced water allowance on the performance of tile drainage system. The specific objectives of the research were (1) to study the effect of heavy rainfall on water table fluctuation and lateral discharge; (2) to investigate the effect of enhanced water allowance on actual drainage coefficient of Shahbaz Ghari Project; (3) to determine the change in salinity/alkalinity of soil and drainage water with respect to increase in water allowance; and (4) to assess the impact of increase in water allowance on cropping pattern and crop yield.

MATERIALS AND METHODS

Description of Swabi SCARP Project

Swabi SCARP falls in the area of Swabi, Mardan, Charsadda Districts as well as Malakand Agency of NWFP. The installation of tile drainage system in Swabi SCARP was started during 1995 and was completed in June 1999 with the objective of lowering the water table from about 1 to 1.5 m more below the ground surface. The project area to North West and East is bounded by Abazai and Machai branch canals of the Upper Swat Canal irrigation system, to the South by Balar drain and to South-West by the Lower Swat Canal (LSC) and Kalpani river. Swabi SCARP Project cover a gross command area of 113,800 ha out of which cultivable command area (CCA) is 79,115 ha. One of the objectives of Swabi SCARP was to increase the water from 4 cusecs per 1000 acres to 9 cusecs per 1000 acres.

Research Site

The research work was conducted at Shahbazi Ghari pilot project area of Swabi SCARP. The research sites I-A and I-C (Plan No. 402) are situated East ward from Mardan about 15 Km away on Mardan-Swabi road. The design depth of the laterals at site I-A was 1.5 m and at I-C was 2 m. The length of laterals varied from 500 to 700 m. Nine laterals were installed at site I-A and eight at site I-C. The spacing varied from 100 to 150 m. Seventeen observation wells at site I-A and twenty five at site I-C were constructed for water table measurement. The construction of the singular sub-surface drain and rehabilitation of Shahbaz Ghari drain was completed in July 1997.

Water Table Depth Measurement

Water table depths were determined from the installed observation wells on weekly basis (Morning, Afternoon) and 2-4 days regularly after rainfall with the help of electrical water level indicator. Actual depth of water table from the ground surface was calculated by subtracting block length of observation well from already measured total water table depth. Average water table depth for the research site was determined by adding all water table depths recorded on a given day and dividing it by the total number of observation wells at the site.

Drainage Coefficient

Drainage coefficient is defined as the depth of water to be removed from the entire drainage area in 24 hrs period. For determination of drainage co-efficient total volume of water discharge from each lateral in 24 hours was calculated. For this purpose an ordinary bucket of known volume was used. Drainage area for each lateral was determined by multiplying length of each lateral with drain spacing. The drainage coefficient was calculated by dividing total volume of flow from each collector per day by the area drained by that collector.

There were nine laterals at site 1-A and eight laterals at site 1-C. Discharge was measured from seven laterals at site 1-A because one lateral was completely dry, and the other lateral had no place to put the bucket for discharge measurement. Similarly at site 1-C only two laterals 1 and 4 were in working condition, the discharge of these two laterals were measured. The rest were either dry or submerged during the study period.

Determination of Electrical Conductivity

Soil samples were collected with the help of soil auger from different locations of the research area. Soil samples were taken in plastic bags while drainage water was sampled in the cleaned, labeled glass bottles, respectively and were brought to the laboratory. Soil samples were taken from 0-0.30 and 0.30 – 0.60 m depths. The soil samples were air-dried, ground and passed through 2mm sieve. Twenty grams of soil was mixed with 100 ml of distilled water and thus a suspension of 1:5 of each sample was prepared of the each sample in separate flasks. The suspensions were transferred to the shaker and stirred for 45 minutes. After stirring, suspension was filtered and the extract was collected for each sample in a separate test tube. EC meter was used to determine the salinity of soil extract. The temperature was adjusted according to the room temperature. Electrode of the digital EC meter was dipped in each solution one by one. Electrical conductivity for each sample in desiSiemens per meter (dS/m) at 25°C was recorded.. Electrical conductivity of water was determined directly by immersing the EC probe in water samples.

Determination of pH

The pH of soil extract and drainage water was measured by pH meter. The extract solution prepared for EC determination was used to determine the pH of soil samples. Soil pH was measured by immersing electrode into the extract solution. The pH meter was first calibrated with buffer solutions of known pH. The reading was recorded to the nearest one decimal place. pH of water was determined directly by immersing the probe of pH meter in water samples.

Cropping Pattern and Yield Assessment

To assess the cropping pattern and yield of major crops at Shahbaz Ghari, a questionnaire proforma was developed. Information on cropping pattern, yield of major crops, condition of salinity, water logging and drainage before and after the increase in water allowance were collected. Thirty farmers were interviewed in the research area.

RESULTS AND DISCUSSION

Fluctuation in Water Table Depth

Figure 1 shows water table fluctuation at site 1-A from ground surface on different dates. Due to simultaneous rainfall events, lowest water table depth (0.54 m) was recorded on 1st September. Highest water table depth (1.34m) was found on 1st October, because of closing (3 to 4 days per week) of distributary. Similarly, in December water table depth was slightly above the design water table depth. It may be due to the cool weather condition and the low evapotranspiration. Irrigation also affected the water table depth and some observation wells were near to the watercourse and after irrigation, the water table rose up. The overall water table depths were lower but closer to the design water table depth, which may be due to the increase in water allowance. The figure show clear effect of rainfall on water table fluctuation. It was noted that after occurrence of rainfall, water table suddenly went up in accordance with depth of rainfall and then fell down after 9-10 hours of rainfall. This shows that the drainage system is functioning well.

Figure 2 shows the water table fluctuation from ground surface on different dates at site 1-C. Lowest water table depth (0.75m) was recorded on 1st September, which was due to the rainfall that occurred at the end of August. Highest water table depth (1.45m) was observed on 5th October. Since the site 1-C is rainfed, therefore overall water table remained well below the design water table depth throughout the study period. Fig. 2 shows clearly the effect of rainfall on water table fluctuation. It was noted that after heavy rainfall, water table went up and light rainfall did not have any significant effect on water table. At site 1-C the water table during the research period was mostly well below the design water table.

Figures 1 and 2 also show water table fluctuation during morning and afternoon. It is clear that overall water table depth in the morning was slightly higher than afternoon. It could be due to the fact that at the morning time weather is cooler and low evaporation occurs from the ground surface. During the afternoon time water table fall down due to warmer temperature and high rate of evapotranspiration.

Similar results were reported by Khan (1999) who studied the performance of subsurface drainage system at Shahbaz Ghari Pilot Project Area of Swabi SCARP. He found that average water depth at site 1-A was lower than design water table depth and the system is functioning well. Similarly the water table depth at 1-C is far below the design water table depth and the system is not functioning well. Khan and Rehman (1997) studied the performance of subsurface tile drainage system of Mardan SCARP. They found that water table was between 1.20 to 2.40 m after the installation of drains.

Drainage Coefficient

Figure 3 shows the fluctuation in the drainage coefficient at site 1-A. Highest drainage coefficient value was shown as 2.51 mm/day in the month of October and lowest 1.36 mm/day in the month of September. The graph shows the change drainage coefficient during the study period. In the months of August drainage coefficient was below the design drainage coefficient (2 mm/day), but after rainfall it went up to 2.13 mm/day and then again dropped below design rate. Drainage coefficient varies with the fluctuation in water table depth when water table rises, drainage coefficient also rises and vice versa. It is clear from the graph, that actual drainage coefficient was slightly below the design drainage coefficient but still working well. Further weekly changes may be due changes in the weather conditions.

Figure 4 shows the fluctuation in drainage coefficient at site 1-C. Highest drainage rate was shown as 1.09 mm/day in the month of August and lowest was 0.24

mm/day in the month of September. After the occurrence of rainfall, the value of drainage coefficient at site 1-C slightly increased, but again dropped. It is clear that the drainage coefficient was far below the design drainage rate (2 mm/day) during the whole research period. It is clear from the Figure that the system is not working well at site 1-C because most of the laterals at site 1-C were in dry condition. Similar results were observed by Khan (1999) who found that the drainage coefficient at site 1-A is closer to design drainage coefficient and the system is functioning well. The drainage coefficient at 1-C is far below the design drainage rate and the system is not working well. Kazmi (1999) studied the performance of composite pipe drainage system at Kalpani pilot project area of Swabi SCARP. He found that actual drainage coefficient of the project area ranged 0.71 to 3.61 mm/day during the study period.

Electrical Conductivity

Electrical conductivity of soil samples which were taken from two depths (0-0.3 m and 0.3-0.6 m) is presented in Table-I. Results show lesser salt concentration in the upper layer (0.71dS/m) compared to lower layer (0.97dS/m). This could be due to the leaching down of salts with irrigation water from the surface in to subsurface layers. Results show that soil at research site is non-saline.

Results regarding ECw of drain outflow from nine laterals at site 1-A are presented in Table-II. The average ECw was 0.93 dS/m which showed that the drainage water has very low salt concentration and can be safely used for irrigation. Results regarding ECw of water from six laterals at site 1-C showed that all water samples have almost similar value. The average ECw value of drain outflow at site 1-C was 0.76 dS/m which fall under low salinity range. Similar results were reported by Asim, (1999) who reported that ECw of drain outflow at site 1-A and 1-C at Shahbaz Ghari Pilot Project area of Swabi SCARP were less saline.

pH

Soil pH was also determined at two different depths (0-0.3 m and 0.3-0.6 m). The pH of soil samples at different depths are presented in Table-I. The average soil pH for both layers was in the alkaline range (8.53-8.64). The higher pH in the lower depth (0.3-.6 m) may be due to lower organic matter in that layer (Kazmi, 1999). Similar results were reported by Asim (1999) who found that electrical conductivity of soil has decreased in top layer at Shahbaz Ghari pilot project area of Swabi SCARP.

Results regarding pH of drain outflow at sites 1-A and 1-C are shown in Table-II. The average pH of drain outflow for both sites was in the alkaline range (8.10-8.11) whereas irrigation water was slightly alkaline (7.38). Similar results were reported by Asim (1999) who found that pH of drain outflow at site 1-A and 1-C were slightly high at Shahbaz Ghari Pilot Project area of Swabi SCARP.

Cropping Pattern

Figure 5 shows the cropping pattern of Kharif season before and after the enhancement of water allowance at the research site. Major crops grown in the area were sugarcane and rice. Percentage of area under sugarcane was highest because it is the major cash crop of the area, and rice was grown for household needs and also sold in the market. In research area, sugarcane was grown on 43% area before increased water allowance, and the percentage of area under sugarcane crop remained the same. Similarly rice was grown on 26% area before increase in water allowance, while it is grown on 29% area after increased in water allowance, its cultivation has increased only on the 12% area. After installation of tile drain rice cultivation has decreased because it required more water in their root zone, but after increased water allowance, its percentage slightly increased. Maize was grown on 16% area before increased in water allowance and its was grown on 21% area after increase in water allowance. Its cultivation has increased 31% area after increase in water allowance. Due to installation of the tile drainage system water table has fallen and the maize crop has grown on large area. Fallow land was 15% before increase in water allowance and 6% after increase in water allowance. Thus the fallow land was decreased after an increased water allowance.

Figure 6 shows the percentage area of crops grown in Rabi season before and after increase in water allowance respectively, at the research site. Dominant crops of Rabi season are sugarcane and wheat. Wheat was grown on 47% area before increase in water allowance and now it is grown on 46% area. Its cultivation has decreased to -2%. Similarly, sugarbeet was grown on 2% area before increased water allowance, and it is grown on 4% area after the increase in water allowance. Its cultivation has increased to 50% area. Garlic was grown on 2% area before and after increase in water allowance. There is no change in Fallow land after increase in water allowance. Result showed no significant change in cropping pattern of Rabi season after increase in water allowance.

Crop Yield

Figure 7 shows the average yield of all the major Kharif and Rabi crops before and after increased water allowance at site 1-A in Shahbaz Ghari pilot project area, of Swabi SCARP. Yield of sugarcane was 40099 kg/ha before increased water allowance and after increase in water allowance it has increased to 46676 kg/ha. The percent of area of sugarcane remained the same but the yield of the sugarcane was (16%) increased with the increase in water allowance. Yield of maize crop was 1094 kg/ha before increase in water allowance, and 1578 kg/ha after increase in water allowance. The yield of maize was (44%) increased but according to the farmers interviewed, its production is still less according to the need. It is due to reason that maize crop is very sensitive to more water in their rootzone. During the growing period of maize, the season is cool and when the rainfall may occur, the water table comes up and it affects the yield of maize crop. The yield of wheat before increase in water allowance was 1828 kg/ha, and after increased allowance, its yield increased to 2508 kg/ha. There is 37% increase in the yield of wheat. According to the farmers interview the production of wheat at Shahbaz Ghari Pilot Project area of Swabi SCARP is significant.

Khan (1999) conducted a research in the same area and concluded that yield of sugarcane was increased after the installation of tile drainage system. He found that the yield of rice was reduced after installation of tile drainage system at Swabi SCARP. Since for best production it need shallow water table, thus after increase in water allowance its production has increased by 24%.

CONCLUSION AND RECOMMENDATIONS

Highest and lowest water table depth at site 1-A was 1.34 and 0.54m and at 1-C it was 1.45 and 0.75m, respectively. At site 1-C average water table depth remained well below design water table depth throughout the study period. The drainage coefficient at site 1-A was closer to the design drainage coefficient (2 mm/day) and at 1-C it was far below the design drainage coefficient. Average ECe and pH of soil at site 1-A was non saline and alkaline in nature, respectively. Average ECw of drain outflow of both site 1-A and 1-C was 0.93 and 0.76 dS/m, respectively, which show that water of both sites was non saline. Average pH of drain outflow at both sites was slightly alkaline with values ranging from 8.10 to 8.11. Dominant crops of the research area were sugarcane, rice and wheat. There was no significant change in cropping pattern, however, the yield of sugarcane, rice, sugarbeet and wheat was 16, 24, 8, and 27% higher after the increase in water allowance. For the sustainability of the tile drainage system, the drain should be cleaned to protect the laterals from submergence.

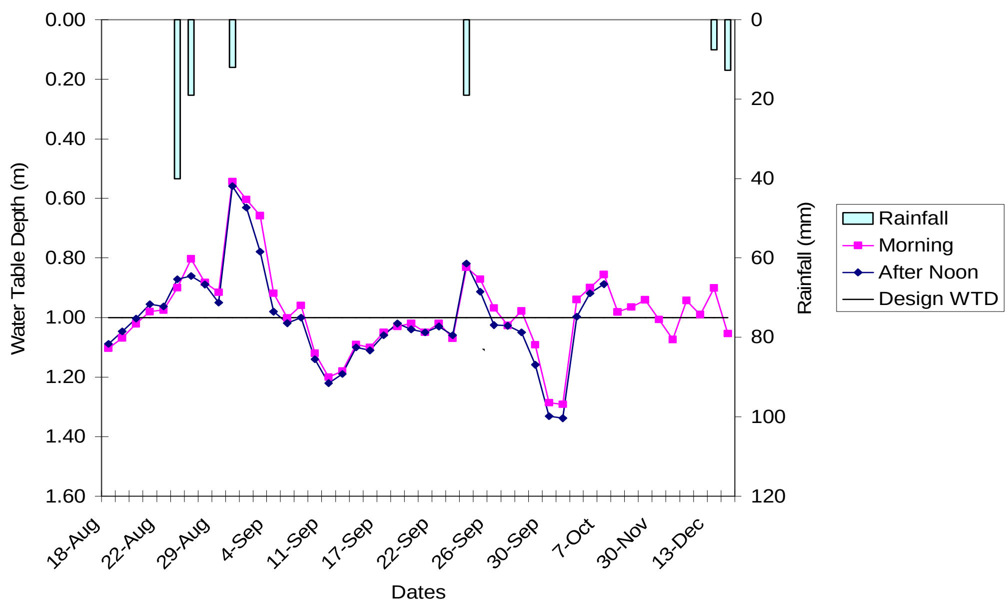

Fig. 1 Water table fluctuation at site 1-A

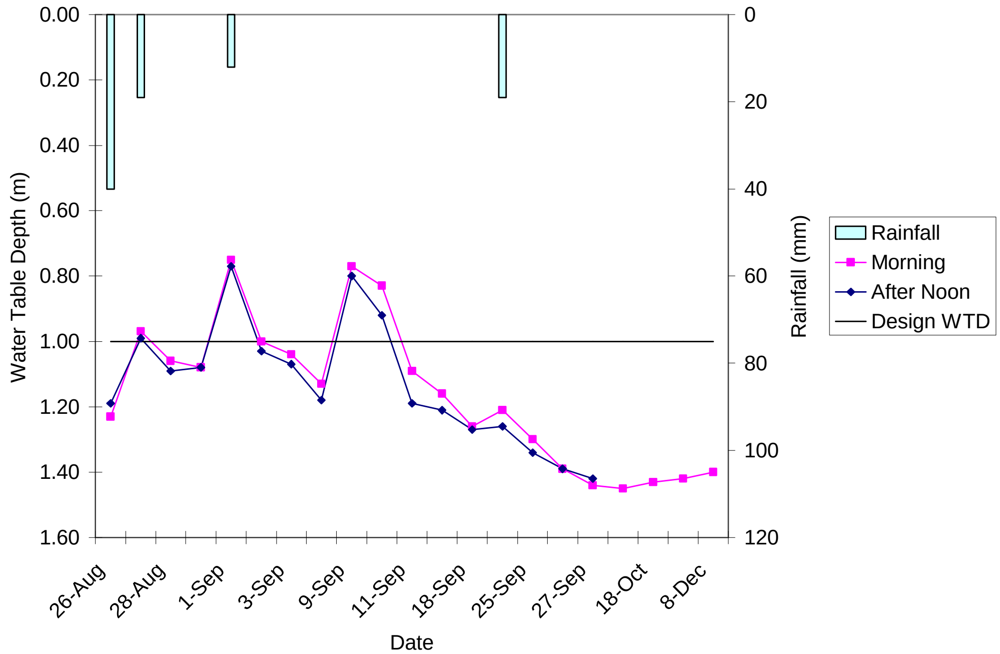

Fig.2 Water table fluctuation at site 1-C

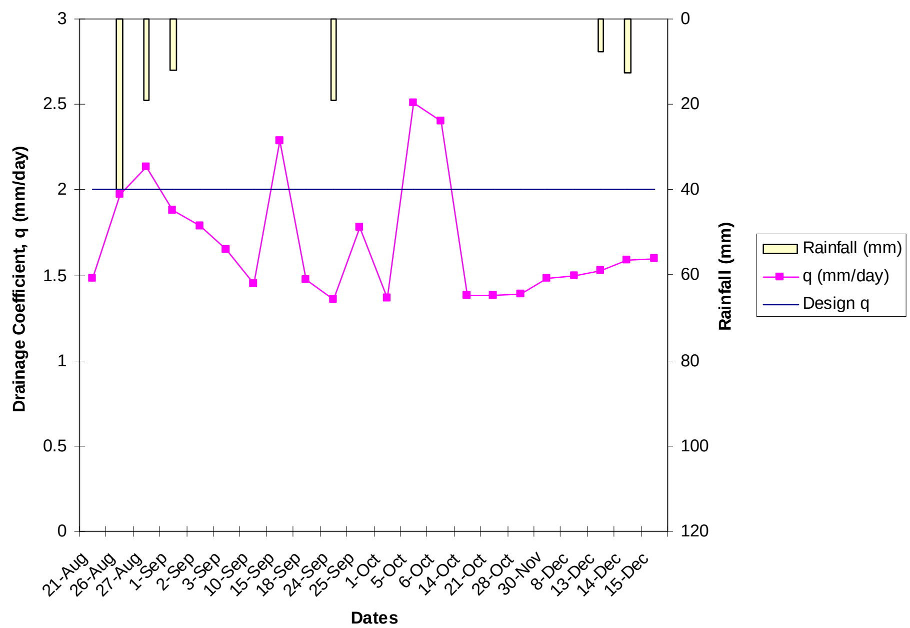

Fig. 3 Actual drainage coefficient at site 1-A

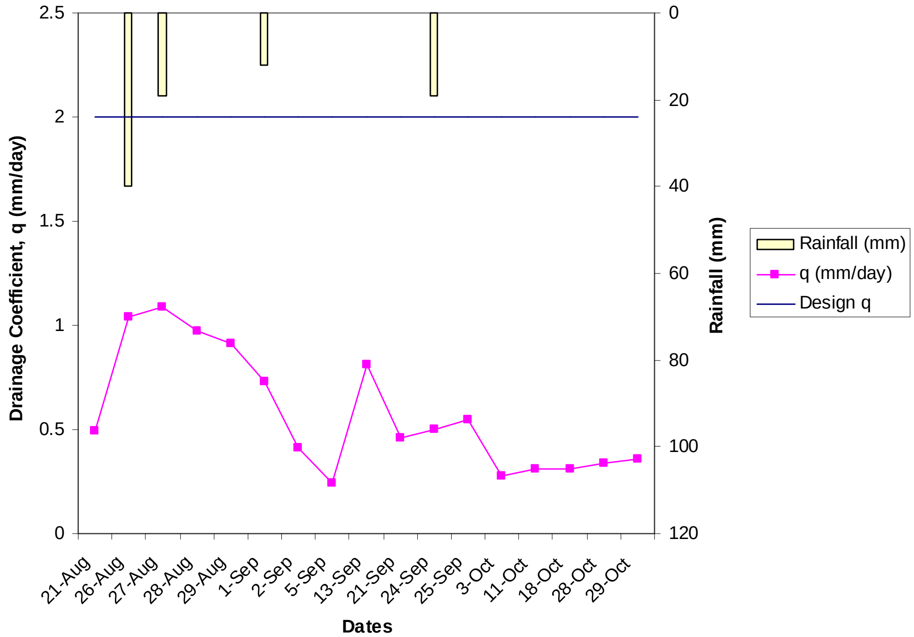

Fig.4 Actual drainage coefficient at site 1-C

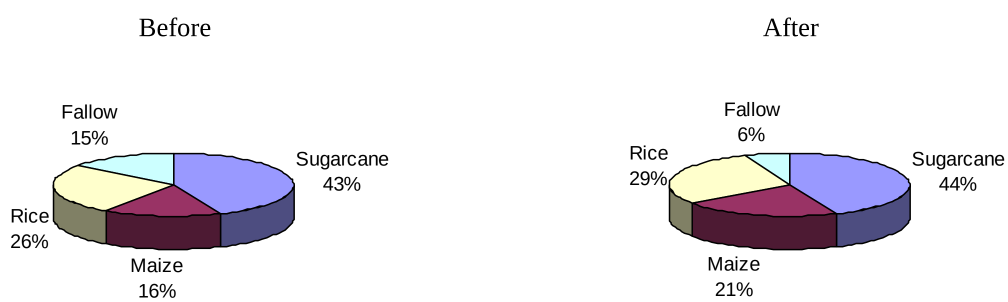

Fig.5 Cropping pattern of Kharif season before and after the increase in water allowance at site 1-A of Shahbaz Ghari Pilot project area of Swabi SCARP

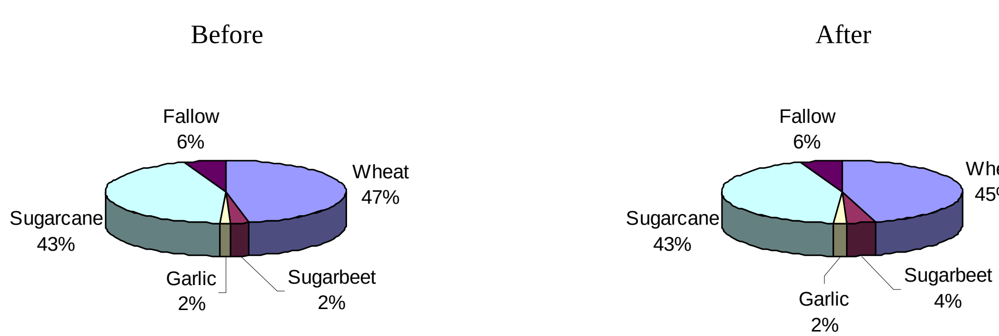

Fig.6 Cropping pattern of Rabi season before and after the increase in water allowance at site 1-A of Shahbaz Ghari Pilot project area of Swabi SCARP

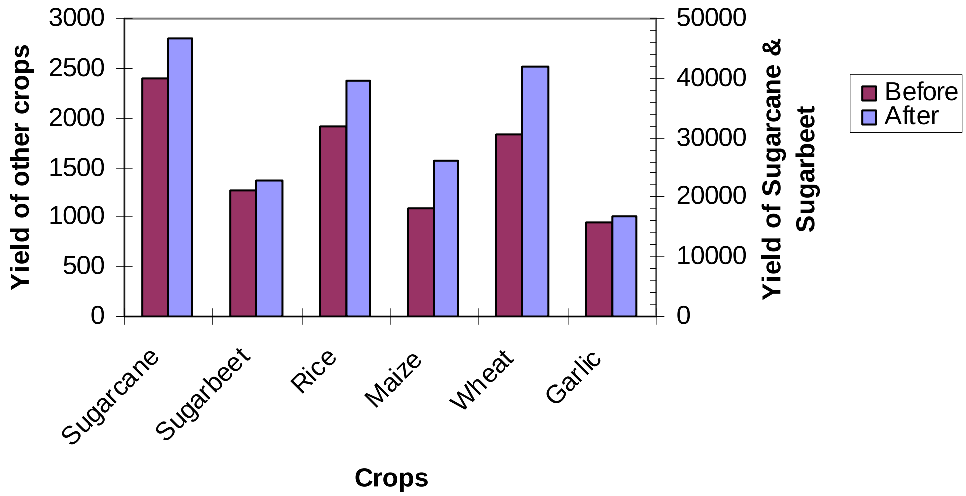

Fig.7 Yield of major crops before and after the increase in water allowance at Shahbaz Ghari Pilot Project area of Swabi SCARP

Table I: ***Electrical conductivity and pH of soil samples***

Location	EC		pH	
	0 – 0.30 m	0.30 – 0.60 m	0 – 0.30 m	0.30 – 0.60 m
Head	0.67	0.79	8.1	8.3
Middle	0.94	0.82	8.4	8.5
Tail	0.51	0.76	9.1	9.2
Average	0.71	0.79	8.5	8.6

Table II: ***Electrical conductivity and pH of drain outflow***

Location	Site 1-A		Site 1-C	
	EC	pH	EC	pH
L1	0.69	8.32	0.72	
L2	0.62	7.87	0.72	8.11
L3	0.44	8.16	0.75	8.25
L4	0.68	7.92	0.82	8.3
L5	0.58	8.47	0.86	7.96
L6	1.34	8.3	0.66	8.01
L7	0.79	7.9		
L8	2.3	8.1		
L9	0.9	7.86		
Average	0.93	8.1	0.76	8.13

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