SOIL AND WATER CONSERVATION RESEARCH INSTITUTE, CHAKWAL

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OVERVIEW

The main soil problems of Pothohar include soil erosion, soil moisture stress and low soil fertility that are mainly caused by uneven topography and poor management of land and water resources of the area. Climate change has resulted in erratic rainfall, longer dry spells and decreased water availability to crops around the world. Rainfed agriculture is more prone to these climatic variations. Major agriculture areas are rain-fed with 60% share in crop production; covering 80 % of global agricultural area. But agricultural production is quite less in arid and semi-arid parts of rain-fed agriculture due to erratic rainfall, poor soil and water management practices. The careful management of these natural resources is essential for food security and environmental protection. Sustainable use of these resources is imperative to socially, economically and ecologically viable communities. High intensity rains generate surface runoff that flashes over sloppy lands. This surface run off when flashes with high speed from higher to lower elevation removes upper soil layer and causes loss of fertile soil and erosion. The rainfall in these areas varies from less than 200 mm to over 1000 mm of which almost sixty to seventy (60-70) percent rain is received in the months of July to September. To address this twin menace of the area Soil and Water Conservation Research Institute was established by the Govt. of Punjab. Main objectives of the institute are; to develop technologies for soil conservation and efficient use of available water for sustainable and profitable crop production. To employ the findings and develop technology for different climatic zones of rainfed area, Soil and Water Conservation Research Station, Fateh Jang and Sohawa were also established. The research stations were upgraded and strengthened in order to boost agricultural production and improve the living standard of the farming community of rainfed tract, through conservation and optimum use of natural resources. The institute has standardized soil and water conservation technologies after extensive research on soil and water conservation keeping in view the specific Agro-climatic zones of rainfed areas. Moreover, the institute has started capacity building of professionals and farmers on various soil and water conservation technologies and trained more than 6000 farmers and professionals.

Role of substrate in decomposition of organic farm waste for improving soil health and fertilityandmaize crop yield

Low fertility and nutrient holding capacity is the major problem of soil in Pothohar area. Therefore, this experiment was designed with the objectives i.e.,(i) to study the effectiveness of farm waste utilization into finished decomposed form; (ii) to find best combination of substrate for fast decomposition process; to identify a suitable and farmer friendly practice and (iii) to develop a workable strategy for increasing organic content of the soil and enhance its nutrient supplying capacity. Among different substrate treatments (urea, sugar, gypsum, rock phosphate), decomposition rate of farm waste was observed under anaerobic conditions and the highest was found under urea application followed by sugar, gypsum and rock phosphate. Analysis of the decomposed material is given in (Table 1).

Table 1. Analysis of decomposed organic material

Detail	pH	EC (dS/m)	Moisture %	Total OM %	C: N
Control	7.08	2.10	40.0	17.5	18.31
Sugar	7.54	2.49	41.2	21.8	18.65
Gypsum	7.51	2.79	44.9	23.7	18.65
Urea	7.61	2.74	45.1	25.3	19.30
Rock Phosphate	7.49	2.69	49.8	28.9	20.81

The decomposed material was analyzed for various quality parameters (Table 1) which revealed that highest amount of total organic matter was found under urea substrate followed by rock phosphate. The decomposed organic material from all the treatments was applied @ 4 t/acre in the field to study their effect on maize yield. Healthy crop stand is visible in Fig. 1.

Fig.1. Effect of substrate compost on maize crop

From the data analysis it was found that the highest maize cob yield was recorded under urea (2.96 t/ha) followed by rock phosphate (2.94 t/ha), gypsum (2.81 t/ha) and sugar (2.41 t/ha) (Fig. 2).

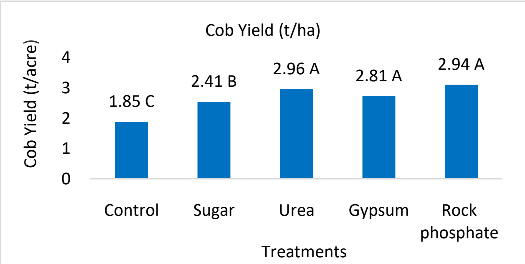

Fig.2.Effect of treatments on cob yield (t/ha).

Impact of organic manures on nutrient loss for sloppy lands

Soil erosion is one of the most significant ecological restrictions to sustainable agricultural production on undulating topography. Unsustainable practices on slope gradients pose a series of problems, such as flood and siltation, for downstream portions of the watershed. In Pakistan, the Pothohar Plateau cover an area of 5.49 Mha, and the agriculture sector is directly or indirectly dependent on rainfall. Almost 60-70 percent rainfall receives in monsoon season. These torrential rains sweep away theessential nutrients from the upper fertile layer of soil. In order to address this concerning issue, no data is available related to soil, water and nutrient losses in the area. In this scenario the study was designed because it is important to manage/solve this issue of sloppy lands.

The results displayed in the following table manifest the similar trend of yield, i.e., at 1, 5 and 10 percent slope gradients, fruit vegetable compost produced highest followed by vermi-compost and farmyard manure.

Table 2. Effect of topography and soil amendment on maize grain yield (kg/ha).

Slope Gradients (%)	Control	FYM Compost	Fruit Vegetable Compost	Vermi Compost
1	2970	3990	6010	5960
5	2210	3570	5530	4770
10	1580	2920	4770	3810

Table 3. Effect of topography and soil amendment effect on ram grain yield (k /ha).

Slope Gradients (%)	Control	FYM	Fruit Vegetable Compost	Vermi Compost
1	1250	1820	1980	2050
5	1220	1430	1470	1730
10	1320	1230	1650	1710

The data recorded from the experiment revealed that at 1, 5 and 10 percent slope gradients, vermi-compost performed best followed by fruit and vegetables compost and farmyard manure.

Fig. 3. Effect of topography and soil amendment on maize crop

Impact of tillage practices and organic manure application on mungbean-sesame intercropping under rainfed conditions.

Tillage practices have been the most common practice adopted for improving soil physical conditions for crop production. Deep tillage enhances the yield by lowering the soil strength and by increasing evapo-transpiration. Deep tillage also increases the moisture reserves in the soil by retaining rainfall.

Table 4. Impact of tillage practices and organic manure application on mungbean-sesame grain yield.

Main Plot	Sub Plot	Grain yield (kg/ha)	
		Mung bean	Sesame
MB Plough	00 t ha^{-1} FYM	634	178
	10 t ha^{-1} FYM	676	190
	20 t ha^{-1} FYM	790	195
Disc Plough	00 t ha^{-1} FYM	620	158
	10 t ha^{-1} FYM	624	171
	20 t ha^{-1} FYM	760	174
Cultivator	00 t ha^{-1} FYM	580	137
	10 t ha^{-1} FYM	610	146
	20 t ha^{-1} FYM	680	142

The data tabulated in the Table 4, elaborated that MB plough along with 20 t ha^{-1} FYM gave maximum grain yield of both crops, followed by Disc plough with same quantity of FYM as compared to cultivator (farmer practice).

Fig.4. Recording data from Mungbean-sesame experiment.

Seed priming to increase adaptive capacity of wheat to moisture stress

One of the important aspects for quality grain production is rapid emergence and good seedling establishment in the field. Therefore, quick and uniform field emergence is essential to achieve high yield in annual crops. The beneficial effect of priming has been demonstrated for many crops such as wheat, soya bean, maize and sun flower. Seed priming has been successfully used to improve germination and seedling emergence of many crops, particularly vegetables and small seeded grasses. Seed priming has been found to be a double technology to enhance rapid and uniform emergence, and to achieve high vigor and better yields in many crop species. It initiates metabolic processes necessary for germination. It is commonly used to reduce the time between seed sowing and seedling emergence and to synchronize seedling emergence. The rationale is that sowing the soaked seed decreases the time needed for germination and may allow the seedlings to escape from the deteriorating soil physical conditions. In addition to better seedling establishment, primed crops grew more vigorously, flower earlier and gave higher yield. It has also been reported that seed priming improves emergence, stand establishment, tillering, grain, straw yieldsand harvest index. Keeping in view the priming on seed germination and further establishment, the experiment was planned to evaluate the effect of seed priming by using water, zinc sulphate, potassium dihydrogen phosphate, urea, ascorbic acid on germination, establishment, yield attributes and grain yield of wheat.

Table 5. Effect of seed priming on reproductive and vegetative growth of wheat

Treatments	Plant height (cm)	Spike Length (cm)	1000 grain wt (g)	Grain Yield (Kg/ha)
Control	86.4	8.0	37.1	3324
Water soaked	89.0	8.5	39.5	3651
Zinc	89.2	8.5	38.3	3980
Phosphorus	89.5	8.5	41.0	3736
Urea	89.8	8.8	43.2	4062
Ascorbic Acid	89.7	8.7	44.2	4080
LSD	2.7	0.8	5.1	516

According to the data analysis presented in Table 6 it was found that the plant height of wheat was maximum with urea-soaked seed (89.8 cm) and spike length (8.8 cm) while 1000 grain weight (44.2 g) and grain yield (4080 kg/ha) was found in the seed primed with Ascorbic acid as compared to the lowest in the control. The Figure 5 shows the process of drying seed after seed primer treatment.

Fig.5. Seeds drying process after giving treatments.

Water productivity enhancement through multiple mulching techniques on millet fodder yield & residual effect on wheat

The pothohar region is facing immense problem of moisture depreciation resulting in lower crop productivity. Different mulching techniques are used to enhance moisture conservation under rainfed conditions. Mulching also reduces erosion while enhancing the soil's ability to hold more moisture and reduces evaporation losses and ultimately reduces the irrigation requirements. It economizes the use of fertilizer and saves labor cost. During the present study various moisture conservation approaches were applied during Kharif on millet crop (harvested at 50% heading stage) and their residual effect was monitored on wheat in Rabi.

Table 6. Effect of different mulching techniques on millet crop

Treatments	Plant height (cm)	No. of tillers $plant^{-1}$	No of tillers m^{-2}	Biomass (t /ha)
T_1 (Control)	182 b	4.4 c	98 b	46.6 d
T_2 (Gyp)	192 ab	4.6 bc	108 b	55.1 c
T_3 (Hydrogel)	196 ab	5.0 b	111 b	57.3 bc
T_4 (Gyp+ Gel)	205 a	6.0 a	134 a	65.5 a
T_5 (Grass)	200 ab	5.6 a	126 a	61.2 ab
LSD	9.8	0.1	15.5	2.1

Table 7. Effect of different mulching techniques on wheat crop

Treatments	Plants m^{-2}	Spike length (cm)	1000- grain wt (g)	Grain yield (Kg/ha)
T1 (Control)	138.33a	7.6c	38.4c	2373c
T2 (Gyp)	141.67a	8bc	38.5c	2482c
T3 (Hydrogel)	140.67a	9.3ab	40.9b	3054b
T4 (Gyp+ Gel)	144.33a	10.7a	43.8a	**3579a**
T5 (grass mulching)	143.33a	9.7a	41.7ab	2958b
LSD	12.4	1.35	2.17	418

According to the data presented in Table 6 and Table 7 it is shown that highest significant biomass yield of millet and subsequent grain yield of wheat was found with gypsum and hydrogel in combination due to enhanced moisture conditions.

Selection and adoptability of effective live barrier grass species for controlling soil and water erosion in degraded lands

The sloppy topography of Pothowar region is immensely vulnerable to water runoff and soil erosion. For the farmers who cannot plain their lands for want of resources but desire to earn some money through raising of field crops, cultivation of grasses on their sloppy lands could be a viable option. The raising of live grasses can save their soils from degradation by preventing erosion of fertile sheet on one hand and can donate them some earning on the other. For this purpose, the adaptability of some palatable grasses was tested for climatic condition of Fateh jang so as to bring them in use as live barriers against water runoff and soil erosion, if their adaptability was found successful for this climate.

The data revealed that all grasses grew well and the maximum biomass yield (6.90 t/ha) was produced by Vetiver. Now the grasses have been shifted to the farmers' fields to monitor other benefits and a model layout was installed at SAWCRS to quantify their shelter against water erosion and protection of arable lands. So, the farmers can protect their lands from deterioration and degradation by growing grasses as shelter belts on their leveled and sloppy lands. Also, they can obtain fodder for their livestock in surplus.

Table 8. Parameters of Grasses Recorded at Medium Rainfall Area during 2021-22

Grass	Plant Height (cm)	Plant Periphery (cm)	Biomass (t/ha)
Paltosa	160	250	3.30
Vetiver	220	260	6.90
Panicum	140	170	3.90
Cenchrus	90	180	3.50
Mott Grass	140	310	5.60
Lemon grass	110	170	4.60

The data revealed in Table 8 shows that the maximum biomass yield (6.80 t/ha) was produced by Vetiver grass. The grasses have now been shifted to the farmers' fields in order to monitor the other benefits and a model layout was installed at SAWCRS to quantify their shelter against water erosion and protection of arable lands. So, the farmers can protect their lands from deterioration and degradation by growing grasses as shelter belts on their levelled and sloppy lands. Also, they can obtain fodder for their livestock in surplus.

Testing and evaluation of locally available super water absorbent for moisture conservation in wheat

Moisture stress is the second most important constraint to agricultural productivity in the Pothohar region. The entire tract is dependent on rainfall for crop production. Mostly, 60-70% of annual rainfall is received during monsoon season. Generally, the rabi crops are more affected by drought, resulting in low yield of crops especially wheat, which is the staple food. Successful crop production in rain-fed areas crop need additional soil moisture from preceding season. It has been reported in literature that polyacrylamides absorb water and may be effective for moisture conservation in rain-fed areas for successful crop production. Therefore, the study was planned to test and evaluate locally available water absorbent in order to enhance soil moisture conservation to improve wheat yield under rain-fed environment.

The results presented in Table 9 indicated that the treatment Hydrogel@ 10 kg ha^{-1} enhanced both grain and biomass yield of wheat by 28% and 17% respectively, over control. However, both treatments (T_3 and T_4) were significantly at par to each other regarding grain yield. Soil moisture percentage was determined though gravimetric method.

Table 9. Effect of differing doses of hydrogel on growth and yield of wheat

Treatments (t/ha)	Plant height (cm)	No of tiller m^{-2}	Biological yield (kg/ ha)	Grain yield (kg /ha)
T_1 (Control)	99.2 b	274.67 b	7670 c	2700 c
T_2 5.0 kg /ha	108.1 ab	276.33 b	8330 b	2830 b
T_3 7.5 kg/ ha	110.0 ab	280.33 a	8980 a	3440 a
T_4 10 kg/ ha	116.3 a	282.00 a	**9010 a**	**3470 a**
LSD	5.41	5.62	423	96

Fig.6. Effect of different doses of hydrogel on wheat growth.

Assessment of water use efficiency and root development in response to N - application in wheat

Wheat is the most important stable food crop in Pothohar, however farming system of the area has the problem of nutrient deficiency and highly variable in rainfall. To overcome nutrient deficiency, nutrients are applied artificially to fulfill the crop requirement. Broadcast and band placement of N fertilizer is common practice in dry land agriculture system but there is a lack of understanding about quantity and fertilizer sources. Plant absorbs soil nitrogen in both $NH_4$and NO_3^- form. Due to nitrification in soil, most of the nitrogen is taken up as nitrates form because nitrates move freely towards plants roots as they absorb water so nitrogen fertilizer sources have a marked effect on crop production but interacts strongly correlated with rainfall. Urea contain nitrogen in the form of NH_3or NH_4 which binds the soil with positive charge and not readily available (may available after nitrification) but calcium ammonium nitrate (CAN) hasnitrogen in both forms i.e NH_4 and NO^-_3that do not bind with the negative charged soils and readily available to plants.

So, the objective of the study was to check effect of nitrogen sources on root development and wheat growth and ultimately crop yield.

Table 10. Effect of different sources of N on crop growth of wheat

Treatments	Roots Length (cm)	Root Biomass (g)	Plant height (cm)	1000 grain Weight (g)
Control	46 b	2.3 b	89 b	31.9 b
Urea	59 ab	4.3 ab	94 a	35.4 ab
HCU	66 ab	4.7 ab	93 a	36.8 a
AS	84 a	5.7 a	94a	38.9 a
CAN	80 a	5.2 a	90 b	37.1 a
LSD	9.2	1.66	2.4	1.54

Table 11. Effect of different sources of N on wheat crop yield

Treatments	Grain Yield (kg/ha)	Straw Yield (kg/ha)	Water productivity (Kg/m^3)
Control	2805 b	4361 c	1.75
Urea	2974 ab	6020 b	1.85
HCU	3012 ab	5985 b	1.88
AS	3728 a	6684 a	2.33
CAN	3229 ab	6125 b	2.01
LSD	166	258	

The data presented in the Table 10 and Table 11 revealed that ammonium sulphate have maximum beneficial effect on root length and crop biomass as compared to the other nitrogen sources. Maybe it is due to the toxic effect of urea to root tips because some time it has been hypothesized that NH_3 is more toxic to plants than NH_4, as urea molecule when applied to the soil surface react with water molecules to form NH_3. The use of ammonium sulphate and calcium ammonium nitrate (T_4 and T_5) also significantly enhanced straw and grain yield of wheat as compared to other treatments and control. Ammonium sulphate has the maximum effect on all yield parameters fallowed by calcium ammonium nitrate and hydrogel coated urea.

Fig.7. Crop data recording of wheat

MISCELLANEOUS ACTIVITIES

1.Organized two Research and development board meetings with the professionals, stakeholder, representees from the farming community to discuss the water saving related issues and research related programs
2. Capacity building of scientists related to advance tools used in the research
3. Submitted two projects in ADP and PARB related to manage water conservation issues in rainfed area

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PROJECT SECTION

ICARDA/USDA, USAID funded Project "Strengthening Agricultural Service Providers (ASPs) capacity to increase adoption of soil fertility & health to improve water quality and conservation techniques" (2018-2021)

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