# PRELIMINARY RESULTS OF AGROMETEOROLOGICAL SOIL MOISTURE CONSERVATION EXPERIMENT AT QUETTA

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## Abstract:

*Quetta represents high elevation agricultural plains of Balochistan Plateau where agriculture is dependent upon rains which are not sufficient to satisfy the water demand of crops. Soil moisture conservation after any wet spell or season had been the top priority of the farming community in such extremely arid climates. Making the best use of conserved moisture for crop production may not be overemphasized. Present study is also an effort to demonstrate soil moisture conservation through simple orientation of sowing practices under farmer's condition without involving any complexity of science. Two years experiment involved the change of conventional north-south orientation of furrows to east-west which saved considerable amount of moisture at early stages of crop development. However, in the top soil layer conserved moisture was less than slightly deeper depth at 10 cm. The result appeared in the form of better crop stand and hence economic yield enhancement.*

## Introduction:

Quetta is located in arid elevated plains of Balochistan. The rainfall amount is not sufficient to meet the overall crop water requirement. Erratic distribution of rainfall over time and space is another constraint on the agriculture production due to degradation of soil, the water holding capacity of the soil is low. The dry and windy conditions results into loss of moisture from upper soil surface at the faster rate. Water deficiency generally coincides with reproductive stages of wheat crop. Fulfillment of water demand of wheat at critical stages of development determines the final yield (Razzaq et. al. 1990).

The rainfall pattern is uni-modal in Quetta. The area receives precipitation only from western disturbance in winter and summer monsoon does not reach there (Chaudry 1992). That is why Rabi crops especially wheat is generally grown in agricultural plains surrounding Quetta valley. Crop production in rainfed areas of Balochistan is relatively more risky as compared to other rainfed plains due to climatic constraints and as such farmers are conservative in use of inputs on their crops (Sheikh et. al. 1988).

Water is considered to be as valuable as gold in dry climates, therefore, search of better and better measures of soil moisture conservation is the aim of scientific community working in such areas. The objective of this experiment was to evaluate different amounts of moisture conserved under two furrow orientations keeping in view the

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characteristics of evaporation from the soil surface exposed to incident solar radiation and wind irrespective of texture and structure of soil.

Present study was conducted in the experimental field of Agricultural Research Institute, Quetta. Wheat was planted on the same date in two different furrow orientations. Both the fields were located side by side at the same level with drill. The furrow orientation in one field was north- south and east-west in the other. The soil moisture was insufficient for seed germination at sowing depth therefore both the fields were irrigated before sowing. Later on crop survived under rainfed conditions.

# Data:

## Phenological observations:

Routine phonological observations were carried out on both the fields at the same time and the data on soil moisture reserves as well as appearance of different phonological phases from emergence to maturity were recorded.Each field was split into four replications. In each replication 10 plants were selected ten days after emergence. They were tagged and future observations were carried out on the same plants. In case of disease attack to a plant or mechanical damage, the plant was substituted with another plant bearing growth and development rate of average plants of the entire field. 10% of the plants in a particular phase considered that phase has set in and 75 % level indicates the phase completion. Subsequently observations on next phase started. In some cases, two phases at a time were in progress. For example, booting and flowering have very short inter-phase duration i.e. one or two days, therefore they coexisted in the field. The summary is given in table-1.

**Table 1:** Degree Days and Inter-Phase Period for Wheat at Quetta

| S. No. | Inter Phase | Period in days (50%) Occurrence of Previous Phase to 50% Occurrence of Present | Degree Days (T-5°C) | Cumulative Frequency Σ (T-5°C) |
|---|---|---|---|---|
| 1 | Sowing – Emergence | 31 | 51.6 | 51.6 |
| 2 | Emergence-Third Leaf | 32 | 21.3 | 72.9 |
| 3 | Third Leaf-Tillering | 23 | 43.9 | 116.8 |
| 4 | Tillering-shooting | 57 | 319.5 | 436.3 |
| 5 | Shooting-Heading | 12 | 167.4 | 603.7 |
| 6 | Heading-Flowering | 13 | 193.9 | 797.6 |
| 7 | Flowering-Milk Maturity | 7 | 93.2 | 890.8 |
| 8 | Milk -Wax Maturity | 6 | 116.3 | 1007.1 |
| 9 | Wax -Full Maturity | 11 | 214.7 | 1221.8 |

## Meteorological Observations:

An agrometeorological observatory is located at a distance of about 100 meters from the experimental field. The meteorological observations were registered daily at 0800, 1400 and 1700 PST. Soil temperature at 5, 10, 20, 30, 50 and 100 cm depths were also recorded daily at 0800, 1400 and 1700 PST. Meteorological parameters recorded at agrometeorological observatory are presented in table-2.

**Table 2:** Summary of Meteorological Parameters recorded at RAMC Quetta

| Month | Temperature (°C) | | | | |
|---|---|---|---|---|---|
| | Daily Mean | Daily Mean Max. | Daily Mean Min. | Wind Speed (km/hr) | Wind Direction |
| Nov. 97-98 | 9.5 | 15.0 | 4.1 | 6.9 | NW |
| Dec. 97-98 | 5.4 | 10.8 | -0.1 | 9.8 | N |
| Jan. 98-99 | 4.5 | 10.3 | -1.2 | 11.8 | NW |
| Feb. 98-99 | 5.9 | 11.6 | 0.1 | 9.3 | NW |
| Mar. 98-99 | 11.1 | 17.0 | 5.3 | 10.3 | N |
| Apr. 98-99 | 18.4 | 25.6 | 11.1 | 11.4 | NW |
| May. 98-99 | 21.9 | 29.5 | 14.3 | 10.7 | NW |
| Jun. 98-99 | 25.0 | 32.3 | 17.6 | 11.0 | NW |

## Soil Moisture:

Soil moisture in different layers of soil at 5, 10, 20, 30, 40 and 50 cm was measured after an interval of 10-days. The famous Gravimetric Method was employed in soil moisture measurements which is on one hand laborious but highly reliable on the other hand. The soil samples were taken with the help of auger on both sides of the furrows in both the fields. Following the standard sampling technique the samples were weighted initially. They were then dried and weighted. Same practice was repeated twice or thrice till the weight became unchanged. The difference of dry and wet weights gave the moisture contents of the individual soil samples. The ratio of moisture contents to dry weight of soil produced the percentage of moisture contents in the soil.

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Comparison of moisture contents of soil (%) in both the experimental plots was carried out in shallow layers of soil (5cm and 10cm depth). The mean deviation during the growing season was also calculated. The results obtained are shown in table-3.

## Analysis of Data

The data on phenological observations were complied for 10%, 50% and 75% phase appearance (50% level is considered to be the phase peak stage). The duration between 50% to 50% consecutive phases was taken as inter-phase period. Inter-phase period gives the idea that how many days were taken to reach the next phase.

The recorded meteorological parameters were also averaged on monthly basis and phase- wise. The combined analysis of meteorological and phenological data helped to understand the rate of growth and development constraints as probabilistic precipitation is not generally sufficient to meet crop water requirement (Chaudry, 1998). The comparative analysis of soil moisture contents in both the furrow orientations was carried out to probe the most feasible way to conserve the available soil moisture. The routine soil moisture conservation practices (mulching etc.) are not acceptable at farmer's level.

Heat units or degree-days concept relates the crop growth and development rate with accumulated heat. The requirement of heat accumulated for advancement of crop from one phase to another differs according to crop/variety. In this study, biological zero for wheat is taken as 5°c and above that summation of temperature is termed as effective heat units.

$K = \Sigma$ (**Error! Objects cannot be created from editing field codes.** - Tb) When **Error! Objects cannot be created from editing field codes.** > 5°c

$K = 0$ When **Error! Objects cannot be created from editing field codes.** ≤ 5°c

Where,
K = Sum of heat units.

**Error! Objects cannot be created from editing field codes.**= Mean daily temperature (°C)

Tb = Biological zero 5°C

Biological zero may be defined as the temperature below which growth of crop does not take place. The crop in both the plot matured at the same time. The accumulated heat units are in given in table - 1

## Result and Discussion:

The results presented in Table-3 show that the soil moisture contents in east-west orientation are slightly more than north-south furrows in identical measurements and exposed to similar environmental conditions. Crop canopy was denser in east-west furrows as compared to north-south furrow orientation plot. Physical health and colour

of plants was better in the former case than the latter one. The grain yield is also higher in east-west case as compared to north-south. Rasul (1993) stated that optimum soil moisture contents at the time of emergence gave rise to good initial establishment of wheat crop ground water rain fed conditions.

**Table 3:** Soil Moisture Measurement in both the experimental plots at Quetta

| Month / Decade | | North–South Furrows (NS) | | East–West Furrows (EW) | | EW / NS Ratio | |
|---|---|---|---|---|---|---|---|
| | | 5 cm | 10 cm | 5 cm | 10 cm | 5 cm | 10 cm |
| December | I | 11.7 | 10.3 | 13.3 | 10.9 | 1.14 | 1.06 |
| | II | 12.0 | 11.7 | 12.9 | 13.5 | 1.08 | 1.15 |
| | III | 9.9 | 7.5 | 9.7 | 10.3 | 1.0 | 1.37 |
| January | I | 9.5 | 7.5 | 9.3 | 10.0 | 1.0 | 1.33 |
| | II | 12.7 | 9.9 | 13.6 | 12.3 | 1.07 | 1.24 |
| | III | 16.9 | 17.2 | 17.5 | 18.9 | 1.04 | 1.10 |
| February | I | 17.0 | 18.4 | 17.9 | 19.9 | 1.05 | 1.08 |
| | II | 13.9 | 15.5 | 14.7 | 16.9 | 1.06 | 1.09 |
| | III | 14.9 | 15.3 | 15.8 | 16.4 | 1.06 | 1.07 |
| March | I | 14.5 | 16.3 | 14.9 | 17.7 | 1.03 | 1.09 |
| | II | 9.5 | 11.4 | 10.8 | 12.6 | 1.14 | 1.11 |
| | III | 8.0 | 10.4 | 9.9 | 11.8 | 1.24 | 1.13 |
| April | I | 7.8 | 9.3 | 9.7 | 10.7 | 1.24 | 1.15 |
| | II | 4.7 | 8.7 | 5.5 | 9.9 | 1.17 | 1.14 |
| | III | 5.1 | 6.2 | 7.4 | 9.3 | 1.45 | 1.5 |

It is important to mention here that furrow height was not abnormally greater than the routine farming practice. The height of furrows after drill-seeding was not more than 8-10 cm in both the cases which were leveled naturally due to wind and precipitation effect later on when crop canopy was around 30-40%. The crop canopy (%) showing the soil cover by plants and general condition of crop in successive development process is given in table – 4. The impact of furrow change was prominent at the initial stages of crop growth and development till crop plants did not fully cover the soil. Ultimately good initial establishment of the crop plants resulted into better yields as the water requirements partially fulfilled at successive development stages throughout the life cycle of the crop.

Orientation of furrows determines the exposure of surface area to the direct sun. The area exposed to sun in case of east-west orientation is less than the north-south because of lower solar angle during winter. Also the duration of exposure is longer in the latter case. Since September equinox (days and nights are equal), the solar angle decreases

gradually and reaches its minimum i.e. winter solistice, the lowest towards southeast on 22nd January. Due to freezing temperatures, the crop growth reaches the slowest stage and northerly winds generally blow during December and January. Under such conditions, the east west furrows remain less exposed to sunshine and wind which are the major factors accelerating the evaporation rate of moisture from the soil surface.

**Table 4:** Visual Observations on Crop Condition of Wheat at Agricultural Research Institute Quetta.

| Date | North – South Furrows | | East – West Furrows | |
|---|---|---|---|---|
| | Canopy | Physical Appearance | Canopy | Physical Appearance |
| | Emergence | Completed | Emergence | Completed |
| after 10 days | 5 % | Good | 5 % | Good |
| after 10 days | 10 % | Good | 12 % | Good |
| after 10 days | 18 % | Good | 25 % | Better |
| after 10 days | 25 % | Fair | 30 % | Good |
| after 10 days | 32 % | Fair | 40 % | Good |
| after 10 days | 45 % | Good | 55 % | Better |
| after 10 days | 55 % | Good | 70 % | Better |
| after 10 days | 68 % | Good | 75 % | Better |
| after 10 days | 75 % | Good | 80 % | Good |
| after 10 days | 85 % | Good | 87 % | Good |
| | 90 % | Good | 90 % | Good |
| Average number of grains per spike | 47 | | 53 | |
| Yield (kg / hectare) | 2854 | | 3049 | |

The evaporation process is the function of solar angle and the exposed area of the surface subjected to evaporation as well as the dryness of adjacent environment (Chaudhry et al 2004). The surface which is exposed to sun for longer time, warms up faster and to higher temperature resulting into higher rate of evaporative loss of moisture from soil surface directly and shallow layers of soil indirectly.

## Conclusion :

The results of this experiment show that some more moisture may be conserved by avoiding solar exposoure and wind effect in upper layers of soil by sowing the wheat crop in east-west furrows instead of north- south furrow; in the dry climates like Quetta and adjoining arid plains. The analysis disclosed that moisture reserves at 10cm depth

are much better than shallow layer of soil. The economic gain of conserved moisture may leave significant effect on future performance of crop through better early establishment and better harvest.

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