and leaves. These stray plant when properly husbanded, gave rise to the first commercial variety of upland cotton in 1914 in the Punjab.

The climatic analogies were used to suggest the introduction of Egyptian cotton into Sindh. The Indian cotton Committee in their report to the Government of India, in 1919, made a general remark that the lower Indus valley was climatically similar to the Nile valley and it was suggested that Egyptian cotton should be tried whenever irrigation became available. Based on these suggestions, Egyptian cotton was introduced in Sindh after the opening of the Sukkur Barrage canals in 1932 . All these efforts failed. The reason was that the Egyptian cotton was grown in the wrong place. A special climatic requirement of Egyptian cotton is that flowering is initiated only when the minimum temperature in the region is 10°C, but without frost during the boll maturation period. Such conditions exist only between Thatta and Kotri where Egyptian cotton has now been found to grow successfully.

Environmental zones of Pakistan and their relation with crop production: Pakistan Agricultural Research Council (PARC) has delineated ten agro-ecological regions of Pakistan based on physiography, geology , climate, agricultural land use and water availability. A brief description of the agro-ecological zones is in the Table 1.5.

TABLE: 1.5: Main features of agro-ecological zones of Pakistan

Zone	*Physiography and climate*	*Soils and land use*
I. Indus Delta	Represent the Indus Delta. Climate arid tropical marine; mean daily max. summer temp. between 34-40°C, and winter temp. between 19-20°C mean monthly summer rainfall 75 mm; and winter less than 5 mm; relative humidity 67-68% in the morning and 30-35% in the afternoon.	Two types of soils; clayey and silty; clay soils found in shallow basins and silty soils in nearly level flat areas; strongly saline-alkali soils are barren and parts of clayey soils are under cultivation with rice, sugarcane, pulses, banana as main crops.
II. Southern irrigated plain.	Represents lower Indus plain formed by the meandering of Indus river. Climate arid sub-tropical continental with hot summer and mild winter; mean daily max. and min. temp. 40-45°C and 8.5°C in the northern areas, and 38-43°C and 8-12°C in the southern areas resp., mean monthly summer rainfall 18 mm in the north and 45-55 mm in the south; winter is practically dry.	Soil is silty and sandy loam, associated with the active flood plain, upper areas of the flood plain calcareous loamy and clayey. Crops grown: cotton, wheat, mustard, sugarcane, berseem on the left bank of the Indus and rice, wheat, gram and berseem on the right bank; sorghum is the main crop in southern Dadu.
III. Sandy desert.	A. sandy desert with xerophtic vegetation; central part occupied by salt lakes; southern part rainfall 300 mm. B. Area covered with various forms of sand ridges and dunes and sand sheets with profuse short trees and vegetation: northern part rainfall 300-350 mm.	Sandy soils and moving sand dunes, undulating sand ridges 20-25 m high and 1-3 m long; western part has strips of clayey soils; land use: grazing. Sandy and loamy fine sandy soil stable ridges; moderately to strongly calcareous, locally saline-sodic, land use: grazing.
IV. Northern irrigated plain.	A. Areas between Sutlej and Jhelum river; different flood plains and bar uplands. Climate semi-arid to arid (east to south west) subtropical continental; mean daily max. (summer) and min. (winter)temp. 39.5° C and 6.2 resp., in the east and 41-42°C and 6°C resp., in the southwest; mean annual rainfall 300-500 mm in the east and 200-300 mm in the southwest. B. Alluvial valleys of Peshawar and Mardan plains. Climate semi-arid subtropical continental; mean daily max.(summer) and min.(winter temp. 43-44°C and 5.0°C resp., mean monthly rainfall range 20-32 mm both in winter and summer.	Southern and central part calcareous silt loams and about 15% saline-sodic; northern part loam and clay loam, mostly non-calcareous, saline sodic in local areas. Canal irrigated agriculture; crops; wheat, rice, sugarcane, oilseeds and millets in the north and wheat, cotton, sugarcane, maize as well citrus and mangoes in the central and southern parts. Central valley silty clays and clay loams. Moderately calcareous with minor salinity sodicity, sloping sides of the valley non-calcareous to moderately calcareous loams. Main crops sugarcane, maize, tobacco wheat, berseem, sugarbeet, considerable areas under fruit orchards (pears and plums).
V. Barani (rainfall) lands	Covers the Salt Range, potwar plateau (generally open and undulating) and the Himalayan piedmont plains. Narrow belt along the foot of the mountains nearly humid, mean daily max.(summer)temp. 38.5°C and min. (winter) temp. 3-6°C; mean monthly rainfall 200 mm in summer and 36-50 mm in winter (Jan.-Feb.). Southwestern part semi-arid and hot.; mean daily max.(summer)temp. 38°C and min. (winter) temp. 4-7°C;	Eastern part dominantly non-calcareous to moderately calcareous silt loams; west southern part mainly calcareous loams. Rainfed agriculture is the main land use and wheat and millets the main crops. Part of the eastern areas irrigated and wheat, rice, maize, millets, oilseeds, pulses grown.

	mean monthly rainfall 85 mm in summer and 30-45 mm in winter.	
VI. Wet mountains.	Covers high mountains (intervened by wide and narrow valley plains) and plateaus. Eastern part humid with mild summers and cold winter;. mean daily max. (summer) temp. 35°C and min. (winter) temp. 0-4°C mountain tops snow clad in winter and spring; mean monthly rainfall 236 mm in summer and 116 mm in winter. Western part sub-humid Mediterranean, with dry summer, rainfall confined to winter and spring.	Soils silt loam to silty clays, non-calcareous to slightly calcareous. Only 25% of the area under rainfed agriculture, the rest under forest; main crops maize and wheat (rice grown in small areas irrigated from springs and streams); fruits (mainly apples) in areas at more than 1500 m altitude: olives grown in low hills; on 1500-5000 m altitude coniferous forests and scrub vegetation and about 5000 m permanent snow.
VII. Northern dry mountains.	Includes Gilgit, Baltistan, Chitral and Dir, valleys irrigated by glacier-fed streams. Climate undifferentiated; tops of high mountains covered with snow greater part of the year; mild summers and cold winters; mean monthly rainfall 25-75 mm in winter and 10-20 mm in summer.	Soils in valleys deep and clayey and on mountain slopes shallow; non-calcareous acid (pH 5.5-6.5) above 2100 m altitude and calcareous at lower altitudes. Most of the area is used for grazing; a part under scrub frost. Wheat and maize grown in rainfed in valleys and lower mountain slopes, and rice irrigated in local areas; fruits grown in flank of streams.
VIII. Western dry mountains.	Composed of barren hills (1000 to 3000 m) with steep slopes. Climate undifferentia-ted; greater part semi-arid highlands with mild summers and cold winters. Southern area mean daily max. (summer)temp. 30-30°C and min.(winter) -3°C to 7.7°C, mean monthly rainfall 30-35 mm. Extreme north western area subhumid, mean daily max. (summer)temp. 32°C and min. (winter) temp. 2°C; mean monthly rainfall 95 mm in summer and 63-95 mm in winter.	Soils in the valleys are loamy, deep and strongly calcareous, mountains have shallow soil. Major land use is grazing; part of the loamy soils grown to wheat with flood water; very small portion is irrigated and fruits (apples, peaches, plums, apricots, grapes), wheat and maize grown.
IX. Dry	Mountainous areas with	Soils in plains silt loams deep

western plateau.	intermountain basins and plateaus, hills generally steep and rugged with narrow valleys in between. Climate arid (desert) tropical; mean daily max. (summer) and min.(winter) temp. 40.5°C and 3-6°C resp., in the north and 33 to 34°C and 11.5-15°C resp., along the coast; mean monthly rainfall 36-37 mm in summer in the southeast and other parts 2.4 mm. Coastal belt receives sea breeze.	and strongly calcareous, and on hill slopes shallow. The lower regions have xerophtic vegetation and grasses and higher altitudes have juniper forests and wild olives. Land use mainly grazing; melons and sorghum quite extensive; fruits, vegetable, and wheat grown where spring or Kareze' water is available.
X. Sulaiman piedmont.	Comprises piedmont plains of the Sulaiman Range and alluvial fans built by streams. Climate arid and hot, subtropical continental; mean daily max. (summer) temp. 40-43°C and min. (winter)temp. 5.8-7.6°C; mean monthly rainfall 13 mm in summer.	Soils loams in gently sloping areas but clayey further away; strongly calcareous, with narrow strips of salinity/sodicity at the junction of piedmont plain and river flood plain. Torrent-watered cultivation is the main land use, and wheat, millets and gram and rice main crops.

(Reference: NFDC, 1996)

Solar energy as a basis for agricultural production: Sunlight is the ultimate source of energy on the earth. Green plants convert solar energy into chemical energy by photosynthesis. The stored chemical solar energy of plants is utilized in different forms by non-photosynthetic organisms. In addition, to photosynthesis, light affects other plant processes including seed germination, vegetative and reproductive growth, and plant morphology.

Solar radiation in the physiology of plant: Solar radiation is energy derived from oscillating magnetic and electrostatic fields present in the sun. It is convenient to discuss the solar radiation important for plant growth in terms of two wave bands, the visible (0.4-0.7 micron), and the infra red (0.7-3.0 micron). The visible band is effective in photosynthesis and is, therefore, often called photosynthetically active radiation. The fraction of radiation intercepted by plants depends on incident radiation, leaf area index, and the canopy architecture of the plant. The latter differs among crops, depending on whether their leaves are erect or horizontal. The crop growth rate (CGR) for a crop intercepting incident PAR completely can be represented by the following formula:

$$CGR = f(\varepsilon, P_{max}, R, K, S_i)$$

Where: ε is a measure of the average photosynthetic efficiency of leaves, P_{max} is the average maximum rate of gross photosynthesis of individual leaves, R is the average fraction of the gross amount of carbon fixed by crop