Nature Farming in Pakistan

T. Hussain and S. Muhammed
University of Agriculture, Faisalabad, Pakistan

Abstract
Small farmers in Pakistan face significant constraints to agricultural production. Productivity has suffered declines due to salinization of soils, loss of soil fertility, and erosion. Farmers without the economic means to buy costly inputs may be able to increase their productivity through low-input, nature farming techniques. Studies have been conducted to determine the efficacy of green manures, farmyard manure, and composts as substitutes for chemical fertilizers. Alternative nutrient sources for fish and animal feeds, and biological control agents are also being investigated. A number of low-cost strategies designed to increase the productivity of small farmers through nature farming are discussed.

Introduction

Pakistan lies between latitudes 24^o to 37^o N, and longitudes 61^o to 76^o E. To its north and northeast are situated the world's loftiest mountain ranges: the Hindukush, the Karkorams, and the Himalayas. For the most part, its western border with Afghanistan and Iran is also rugged mountainous country. Its northern and western sections are crossed by a number of passes. All these physical features have a great bearing not only on the temperature and rainfall pattern of Pakistan, but also on the general circulation of the atmosphere over southern Asia.

Diversity and conspicuousness of landscape are the two outstanding physiographic features of Pakistan. Prolonged organic disturbances, changing climate, unique hydrologic features, and human activity have played significant roles in sculpturing the landmass of Pakistan. Geographically, Pakistan has a highly diversified landscape and environment. Snowclad mountains, vast sandy deserts, extensive river systems, and piedmont plains have combined to give rise to a wide range of agricultural soils. Pakistan’s soils can be divided by ecological regions: the northern mountainous region, western mountainous region, potwar upland, sandy deserts, piedmont plains, old river terraces, sub-recent river plains, recent river plains, and the Indus Delta (Figure 1).

Agricultural Resources and Production

Soil

The total geographical area of Pakistan is 79.6 M ha, whereas the cultivated area is only 20.7 M ha which is about 20 percent of the total area (Table 1). There is another 9.51 M ha which is categorized as culturable wasteland. Out of the total cultivated area, about 4.70 M ha remain fallow. This leaves a net sown area of 16.0 M ha of which 4.81 M ha are cropped more than once, thus raising the total cropped area to 20.8 M ha. The rainfed area constitutes about 20 percent of the cultivated land.

Table 1. Land Utilization in Pakistan During 1986-87. (Agricultural Statistics of Pakistan 1987- 1988).

Geographical Area	Forest	Culturable Wasteland	Cultivated Land	Current Fallow	Rainfed Area
		M ha			
79.6	3.06	9.51	20.7	4.70	4.13
Net Area Sown	**Total Cropped Area**	**Salt-Affected Area**	**Waterlogged (1975)**	**GCA***	**CCA****
		M ha			
16.0	20.8	5.8	7.0	17.0	14.0

* Canal Command Area
** Culturable Canal Command Area

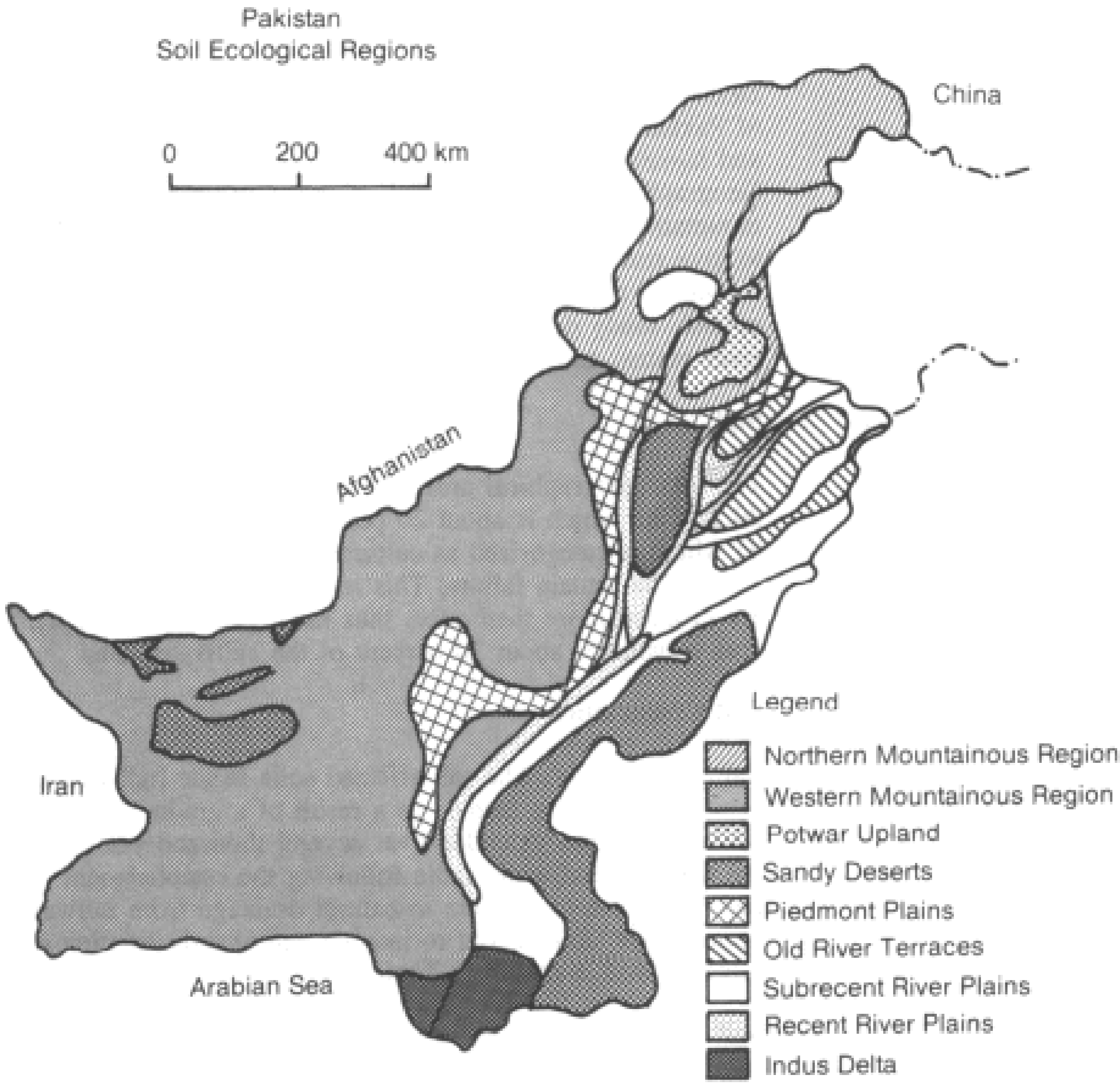

Figure 1. The Soil Ecological Regions of Pakistan

Soil Constraints

Salinity/Sodicity. The salt-affected soils in the Indus Plain occur in specific physiographic positions and were formed as a result of a gradual redistribution of salts in the landscape. This process has extended over several thousand years but has been hastened by the rise in the underground water table following the establishment of extensive irrigation systems and the emergence of barriers to natural drainage from railway and road networks. Thus, the rising water table served to intensify an already existing condition. The extent of salt-affected land is shown in Table 2.

Table 2. Extent of Salt-Affected Land in Pakistan.

	NWFP*	**Punjab**	**Sind**	**Total Indus Plain**
			10^3 ha	
Total CCA**	320	7890	5350	13600
Within CCA: Salt-affected area	14	1610	1530	3160
Outside CCA: Salt-affected	502	1130	1020	2650
Total salt-affected area	516	2740	2550	5810

* NWFP: North West Frontier Provinces.

** CCCA: Culturable Canal Command Area

Soil Fertility Problems. The soils of Pakistan are generally calcareous, with high pH and low organic matter content (1ess than 1 percent), and are known for their high phosphorus fixing capacity. Thousands of fertilizer experiments conducted at research stations, farms, and in the farmers' fields since 1950 have confirmed widespread deficiencies of nitrogen and phosphorus. Still there are some areas, particularly sandy soils and tubewell commands, where crop response to potassium is common. Deficiencies of zinc and iron have been identified in rice and fruit crops.

Soil Erosion. Soil erosion is another important aspect adversely affecting the productivity of our cultivated soils. Water and winds are imperceptibly eroding the upper fertile parts of the cultivated soils. The process of erosion is more active on sloping lands. Estimates by the Punjab Agricultural Economic Information Board indicate that about 1.4 M ha are affected by erosion in the Punjab alone which accounts for 17.7 percent of the total area of 11 affected districts. In the North West Frontier Provinces (NWFP) about 9,400 ha are severely eroded.

Irrigation Water

The development, use, and distribution of the physical resources, namely water and land, have played a major role in the process of agricultural development in Pakistan. Pakistan's agriculture is mostly irrigated. Our surface irrigation system is dependent upon the Indus River and its two tributaries, i.e., the Jehlum and Chenab. The system consists of three storage reservoirs, namely Tarbela, Mangla, and Chashama; 16 barrages, 12 inter-river link canals, two syphons, and 43 main canals. The total length of the canal system is about 50,315 km, with 88,600 outlets. The length of the farm channels and water courses is 1.6 million km. Water flows by gravity from northeast to southwest. Although this is one of the most magnificent irrigation systems in the world, it has problems of transit losses of water from seepage and evaporation which amount to a 40 percent loss from canal headworks to the farmgate. The farmgate availability of canal water is 70 million acre feet (MAF) compared with 98 MAF at the canal head. Another source of irrigation water is ground water which is mostly saline or saline-sodic, but about 40 MAF of good quality water was pumped for irrigation during 1986-87 from 250,000 tubewells.

Crop Production

Agriculture was the dominant sector of the economy after independence in 1947, contributing about 53 percent of the Gross Domestic Product (GDP). Its share of the GDP has inevitably fallen as other economic sectors such as manufacturing, construction, and services, which were rudimentary at the time of independence, were developed on a priority basis. Nevertheless, agriculture continues to remain the single largest sector of the economy. It contributes 26 percent of the GDP and provides employment to over half the country's labor force. Agriculture and agro-based products account for 80 percent of the country's total export earnings and this sector supplies many of the major industries with raw materials. In turn, agriculture consumes 33 percent of the industrial finished goods. Almost 70 percent of the country's population continues to reside in the rural areas.

Table 3. Food Grain Production in Pakistan in 1987-88 (Agricultural Statistics of Pakistan 1987-88).

Crop	Area	Production	Yield
	10^3 ha	*10^3 Mg*	*kg ha^{-1}*
Wheat	7310	12700	1730
Rice	1960	3240	1650
Corn	854	1130	1320
Millet	293	135	462
Sorghum	320	181	565
Barley	145	112	771
Total Food Grain*	10900	17500	-

* Totals may not be precise due to rounding.

The climate of Pakistan is suitable for growing a number of crops such as wheat, rice, millet, corn, sorghum, and barley as food grains (Table 3); sugarcane, cotton, tobacco, jute, and sugarbeet as cash crops; gram, mungbean, mash bean, lentil, peas, and some others as pulses; and rapeseed, mustard, sesamum, groundnut, soybean, sunflower and safflower as edible oilseeds (Table 4). Apart from this a number of fruits including citrus, mango, banana, apple, guava, apricot, peach, pears, plums, grapes, pomegranate, dates, and almonds, and a wide variety of vegetables are also grown (Table 4). Distribution of the cropped area, as recorded in 1986-87, was 56, 16, 7, 2, 2, and 1 percent for food grains, cash crops, pulses, oil seeds, fruits, and vegetables, respectively, with an additional 16 percent for other crops.

Table 4. Production of Cash Crops, Pulses, Edible Oils, Fruits and Vegetables in Pakistan in 1986-87 (Agricultural Statistics of Pakistan 1987-88).

Crop	Area	Production
	$l0^3$ ha	*$l0^3$ Mg*
Cash crops	3470	42200
Pulses	1220	557
Edible oils	4000	307
Fruits	427	3590
Vegetables	249	3080

Livestock Production

The livestock sector contributes some 31 percent of the agricultural value added. The present role of the livestock sector in the economy of Pakistan reflects the historic role and importance of livestock and their products in the rural economy. The primary purpose of livestock-keeping has been, and largely still is, to supply basic dietary needs to the farm family as well as draft power, with the generation of cash income as a secondary objective. The close integration of the livestock sector with the rural subsistence economy is made possible by strong reliance of livestock on the cultivated regions for crop residues and fodder crops. Rangelands provide the other major source of animal feed. On this basis it has been possible to meet the minimum dietary requirements for animal protein and fats that supplement the cereal staples which have traditionally dominated the diet. The present availability of feed and fodder consists roughly of one-third from crop residues, one-third from grazing, and the remainder from other crop by-products, all expressed in terms of the total digestible nutrients (TDN). Livestock populations in 1976 and 1986 along with inputs and outputs in 1986 appear in Table 5.

Table 5. Livestock Populations in Pakistan and Production Inputs and Outputs for 1986.

Livestock	Number		Animal Units	Feed Intake		Output	
	1976	1986*		TDN**	DP***	Meat	Milk
	10^6		*10^6*	*10^3Mg*		*10^3Mg*	
Cattle	14.8	17.6	16.1	18.4	1.56	340	2830
Buffalo	10.6	15.8	15.9	20.0	1.77	270	8640
Goats	21.7	30.3	2.87	3.33	0.27	230	743
Sheep	18.9	23.5	2.34	2.92	0.23	165	30
Poultry	32.0	137	1.20	2.71	0.39	135	(8630)#
Others##	3.66	4.60	4.60	4.37	0.33		
Total###			43.0	51.7	4.55	1140	12200

* TDN: Total digestible nutrients.
** DP: Digestible protein.
*** Camels horses mules etc.
\# Production of eggs (Million).
\## All other values reported here are for 1986.
\### Totals may not be precise due to rounding.

At present, the milking animals consume about 38 percent of all the available feed and fodder. Full feeding would require that 55 percent of all feed and fodder would be consumed by dairy animals, furthermore reducing the already meager diet of the other animals. In any case, it is clear that the most efficient way to increase milk production is by providing larger quantities of feed and fodder to the present stock of milking animals. The main problem is limited feed resources and increasing animal numbers. There are about 0.42 million Mg of fish produced in the country. The consumption of fish products is very low in Pakistan, about 1.1 kg per capita annually. This is due partly to the somewhat insular dietary habits of Pakistan and partly to the high price of fish.

Forestry

Together with watersheds and rangelands, forests are a vital component of the ecosystem of the country, As a discipline, forestry is closely interconnected with soil resources, water management, wildlife conservation, and livestock. As little as 5.2 percent of Pakistan's total area (including Azad Kashmir) is forested. However, only about 30 percent of this total is economically utilized while the balance is basically under protective management. Out of the total forest area of 4.85 M ha, 3.30 M ha are state owned and the remaining 1.55 M ha, though mainly managed by forest departments, are privately owned.

The annual per capita domestic energy requirement is equivalent to 0.4 m^3 of fuelwood. For a population of 98.4 million in 1984-85, the fuelwood requirement was 39.4 million m^3. Approximately 53 percent of these requirements are being met from such sources as kerosene oil, natural gas, coal, cow dung, and agricultural residues, while the rest are met from fuelwood. Fuelwood consumption in 1984-85 was estimated at 19.7 million m^3.

Farm Business in Pakistan

Farming in Pakistan is done in a physically demanding environment. This is the case for both irrigated as well as rainfed agriculture. The rural population, labor, and unemployment figures appear in Table 6. The most serious inequities at present exist in the rural areas mainly because of Pakistan's inherited land ownership pattern. About 38 percent of the total cultivated area is operated by 73 percent of the farmers with an average holding of 5 ha or less (Table 7). The remaining 62 percent of the cultivated area is operated by only about 27 percent of the farmers with average size farms of 5 ha or more. The basic inequity among landholders is clearly reflected in the differences in their respective economic and social positions. The larger landowners have ready access to water, credit, fertilizers, and other resources. By comparison a sizable proportion of the small farmers do not have comparable access to credit (Table 8) and are unable to manage inputs efficiently. This results in higher production costs per unit area or per unit of output. The small farmers reap relatively poor yields and receive lower prices in the marketplace for their output than the large farmers. A major part of the products such as milk, meat, vegetables, maize, pulses, and millets are raised by small farmers. However, there are neither officially fixed prices nor any procurement programs for these commodities. As a result, market margins may go as high as 50 to 60 percent as compared with 10 to 15 percent for commodities for which officially fixed prices and procurement programs have been arranged.

Table 6. Population, Labor and Employment Status in Rural and Urban Areas of Pakistan in 1987-88 (Agricultural Statistics of Pakistan 1987-88)

	Total Number	Rural	Urban
		10^6	
Population	84.2	60.4	23.8
Labor force	30.5	18.9	11.6
Small livestock holders (landless)	1.5		
Landless	0.5		
Population growth rate, %	3.1		

Table 7. Number and Area of Private Farms Classified by Size (1980).

Farm Size *Ha*	Farm Number 10^6	%	Farm Area *M ha*	%	Cultivated Area *M ha*	%
Under 0.5	0.33	8	0.10	N*	0.09	N
0.5 to under 1	0.37	9	0.28	1	0.25	2
1 to under 2	0.69	17	0.97	5	0.89	6
2 to under 3	0.68	17	1.63	9	1.51	9
3 to under 5	0.92	23	3.57	19	3.28	21
5 to under 10	0.71	17	4.70	25	4.12	26
10 to under 20	0.26	6	3.39	18	2.78	17
20 to under 60	0.10	3	2.80	15	2.03	13
60 to above	0.01	N	1.62	8	0.92	6
All farms**	4.07	100	19.1	100	15.9	100

*   N: Negligible
** Totals may not be precise due to rounding.

Table 8. Availability of Institutional Credit by Farm Size in the Punjab (Census of Agriculture, 1980).

Farm Size	Total Credit %	Loan Size *Rs farm^{-1}*	Index*
Small	3.9	66	100
Medium	35.4	320	485
Large	60.7	3260	4930

* Small farms = 100.

Constraints of Small Farmers

A small farmer's ability to raise his productivity and income level is constrained by the following factors:

1) **Agronomic-Technological Constraints.** These constraints have to do with the quality of land, including location and soil fertility, amount of water available, cropping practices, incidence of diseases and pests, and limited availability of agricultural technologies adapted to small farm conditions.
2) **Economic Constraints.** These have to do with the conditions of markets (prices they receive and pay) and incentives (subsidies and taxes). The small farmer does not have the financial means to make the necessary inputs at the proper times. He is forced to sell a large portion of his output at harvest time and often at low prices to settle his outstanding accounts.
3) **Structural-Institutional Constraints.** These include small holdings and their fragmentation, insecurity of tenure, access to extension services, credit, storage facilities, transportation, infrastructure, and unfavorable public policies.
4) **Socio-Political Constraints.** Small farmers have no organization and no power to influence governmental policies in their favor. Large farmers and large landlords have major claims to economic and social power and, hence, leadership. Unfortunately, the agriculture-oriented institutions are not structured or organized to accommodate the interests of small farmers. Even those few schemes designed to benefit the small farmers neglect to involve them in either the planning or implementation phases and the program usually fails.

Under the above mentioned unfavorable farming infrastructure, a revolution in agricultural production is only possible if low external input technologies for crop and livestock production are developed with the small farmer as the principal recipient, although large farmers would also benefit. The proposed strategy demands an interdisciplinary approach by the scientists of various agricultural fields.

The principal theme behind the strategy is the concept of nature farming which is a system of practicing maximum agricultural production, making the best possible use of the natural agroecosystem and environment. In this system the fertility is restored by using farmyard manures (FYM), composts, green manures, industrial wastes, and other plant nutrient sources. Plant diseases are controlled through the genetic diversity of the cropping system, spraying of extracts of indigenous plants, allelopathy, and other natural controls. This system encourages farmers to make the best use of all crops and livestock products and their natural interdependence. It also encourages us to explore fully the agricultural potential of an environment with minimum use of external and costly inputs. Although many farmers claim to have practiced some of the techniques used in nature farming, few if any have followed a holistic approach to nature farming.

Nature Farming

Some of the work done in Pakistan on aspects of nature farming is as follows:

Replacement of Chemical Fertilizers with Biofertilizers

Green manures when integrated with chemical fertilizers can increase N use efficiency and the yields of rice and wheat (Tables 9, 10). A number of green manures like *Sesbania aculeata* (cannabina), *Sesbania rostrata*, *Crotalaria juncea* (sunnhemp), *Cyamopsis tetragonoloba* (guar), *Leptochloa fusca* (Kallar grass), *Cajanus cajan* (pigeon pea), and *Pennisetum typhoides* (pearl millet) are being evaluated as substitutes for chemical fertilizers. It has been found that 60 to 70 kg N ha^{-1} can be replaced by green manuring of *S. aculeata* and *S. rostrata*.

Table 9. Grain Yield of Rice and Wheat as Affected by Green Manure Replacement of Chemical Fertilizers (Nabi, 1985; Zaka, 1986).

Treatment	Paddy Yield*		Wheat Yield**	
	1985	1986	1985-86	1986-87
	Mg ha^{-1}		*Mg ha^{-1}*	
Check	3.96c***	3.40c	3.58d	3.27c
PU****	5.29b	4.50b	5.22c	3.96b
S. aculeate + PU	5.19b	5.23ab	5.91c	4.56a
S. rostrata + PU	5.56a	5.60ab	4.37bc	4.40a
FYM + PU	5.14b	4.78b	4.74ab	4.37a
Sunnhemp + PU	-	5.88a	-	4.20ab
Guara + PU	-	5.53ab	-	5.50a
Rice = KS-282, Wheat = Pak-81, Soil (Typic Camborthids)				

* 87 kg N ha^{-1}.
** 1l6 kg N ha^{-1}.
*** Column values followed by the same letter are not significant]y different at the 5% Probability level.
**** PU, prilled urea.

Table 10. Grain Yield of Rice as Affected by Green Manure/FYM Replacement of Chemical Fertilizers (Sadoki Farm – NARC, 1988).

Treatments	N Rate	Grain Yield
	kg ha^{-1}	*Mg ha^{-1}*
Check	-	3.92
AS*	90	6.68
AS + *S. aculeata*	90	7.88
AS + Straw (10 Mg ha^{-1})	90	7.21
AS + FYM (10 Mg ha^{-1})	90	7.71
PU*	90	6.33
PU + *S. aculeata*	90	7.38
PU + Straw (10 Mg ha^{-1})	90	6.75
PU + FYM (10 Mg ha^{-1})	90	7.08

* AS, ammonium sulfate. ** PU, prilled urea

Farmyard manure (FYM) and composts are good substitutes for chemical fertilizers. There is a tremendous potential for producing greater amounts of FYM. The statistics indicate that the annual production of N, P_2O_5 and K_2O from animal manures is 1.75, 0.688, and 1.80 million Mg, respectively. These figures are actually greater than the annual chemical fertilizer consumption of these same nutrients which is estimated at 1.33, 0.409, and 1.78 million Mg, respectively (Table 11). In experiments where FYM was applied in lieu of chemical fertilizers, it was found that 5 Mg ha^{-1} of FYM can replace 60 kg N, 40 kg P_2O_5 and 30 kg K_2O (Table 12).

Table 11. Increase in Fertilizer Consumption, Production, and Importation in Pakistan Since 1970-71. (Pakistan Economic Survey 1987-88).

Year	Consumption					Production	Importation
	N	P_2O_5	K_2O	Total	Increase		
	10^3 Mg				*%*	*10^3 Mg*	
1970-71	252	30.5	1.2	283	-	133	151
1975-76	445	102	2.8	551	94.4	327	182
1980-81	843	227	9.6	1080	96.0	640	574
1985-86	1130	350	33.2	1510	40.0	1130	331
1986-87	1330	409	42.6	1780	18.0	1210	522

Table 12. Replacement of Chemical Fertilizers by FYM for Rice and Wheat in a Ustalfic Haplargid (Zaki, 1989).

Treatment $N-P_2O_5-K_2O$	Rice Yield Cv. Bas-370	Wheat Yield Cv. Pak-91
kg ha^{-1}	*Mg ha^{-1}*	
0-0-0	1.64e*	3.20f
120-0-0	1.94e	3.58e
120-80-0	3.36bc	4.57b
120-0-60	3.00d	3.68d
0-60-80	3.01cd	3.78c
120-60-80	3.50b	4.72a
120-80-60 + FYM (10 Mg ha^{-1})	4.15a	4.83a
60-40-30 + FYM (5 Mg ha^{-1})	4.41a	4.57a
FYM (10 Mg ha^{-1})	4.42b	4.08bc

* Column values followed by the same letter are not significantly different at the 5% Probability level.

Replacement of Chemical Amendments by Physical and Biological Treatments

Studies were conducted on the reclamation of coarse-textured, saline-sodic soil with rice cropping. The yield of rice was significantly higher where subsoiling was done compared with the application of gypsum.

Replacement of Maize Grain with Manure-Molasses Silage

This was done for feeding broiler chicks with regard to weight gain, feed consumption, feed efficiency, and cost of production. The rations containing 12.5 percent dried cattle manure-molasses silage in place of maize grain, on a protein basis, resulted in higher weight gain and net returns (Table 13). Further increase in the percentage of manure caused a reduction in live weight.

Replacement of Commercial Fish Feed with Poultry Droppings

Results have shown that 43.2, 41.4, and 1.9 percent higher fish yields were obtained when broiler manure, layer manure, and cow manure were used in place of commercial fish feed (Table 14).

Table 13. Replacement of Maize Grain with Manure - Molasses Silage for Broiler Chicks (Ali, 1987).

Ration	Avg. Wt. Grain/ Bird	Avg. Feed Consumed/ Bird	Avg. Feed/ Bird Wt.	Cost of Feed	Cost of Prod.
	g	*g*	*g g^{-1}*	*Rs kg^{-1}*	*Rs*
Maize gram	1470	3240	2.21	3.47	7.68
Manure silage, 12.5%	1530	3700	2.41	3.23	7.80
Manure silage, 25%	1460	3700	2.53	2.90	7.37

Table 14. Fish Yields Obtained from Replacement of Commercial Fish Feed with Poultry Manure and Cow Manure (Javaid, 1989).

Treatments	Broiler Manure	Layer Manure	Cow Manure	Commercial Fish Feed	Control
% N	4.60	3.84	1.48	4.80	-
% P	1.62	1.84	1.08	2.85	-
% K	1.32	1.20	1.27	0.98	-
Fish yield, kg ha^{-1} yr^{-1}	5060a*	4880b	2930c	2870d	767

* Row values followed by the same letter are not significantly different at the 5% probability level.

Studies on Plant Derived Pesticides

Extracts of indigenous plants such as neem (*Azedirachta indica*) are being evaluated as biological control agents. They are using different mixtures of different crop species or varieties which could buffer against disease losses by delaying the onset of the disease, reducing spore dissemination, or modifying conditions such as humidity, light, temperature, and air movement. They are also interested in some of the associated plants which can function as repellents, antifeedants, growth disrupters, or toxicants in an effort to avoid using poisonous chemicals which can kill beneficial insects, natural predators, and soil microorganisms.

Other Strategies to Strengthen Natural Farming in Pakistan

Agriculture in developing countries has to function under a wide range of conditions and, consequently, must use a number of different strategies. Diversity is very important for the farm unit to ensure the best possible use of internal and external factors like climate, soil conditions, markets, communications, capital, labor, and time.

The following measures can certainly help the economic revival of the small farmer as well as help to sustain agricultural productivity through nature farming:

1) Development of local agricultural technologies suitable for small farms based on local natural resources, climate, landscape, soil, water, indigenous vegetation, and animals and human resources such as labor, experience, and skills. The use of external inputs such as commercial fertilizers and pesticides should be minimized as far as possible for economic reasons in order to satisfy criteria of ecological sustainability, and to enhance the health and independence of the farmers. Indigenous knowledge of the agroecological system, traditional methods of agriculture, and local forms of farmers' organizations are the starting points from which new technologies based on scientific insights and experiences in comparable situations can be developed.
2) Adoption of high value and short duration crops like vegetables, fruits, and edible oils.
3) Adoption of agroforestry so as to integrate trees into cultivated fields or farming systems to improve soil fertility and microclimate, to prevent soil erosion and produce fuelwood, timber, fodder, or edible products.

4) Adoption of integrated pest management in which pests are countered by a mixture of preventive, mechanical, biological, and chemical means.
5) Adoption of integrated nutrient management in which soil is kept healthy and its fertility is enhanced by means of organic fertilization through a number of natural processes such as buffering, nutritive capability of organic materials, nitrogen fixation by means of bacteria, and recycling plant nutrients from below the rooting zone by means of deep-rooting crops.
6) Adoption of multiple cropping systems in which optimum use is made of light, space, and nutrients.
7) Recycling of nutrients by returning crop residues and the organic wastes from food processing back to the field.
8) Integration and coupling of livestock-fish-poultry operations and crop production systems to maximize the utilization of wastes and by-products from one component as production inputs for another.
9) Adoption of water and nutrient harvesting in rainfed areas with the use of special structures to capture runoff and nutrients.
10) Microclimate management by using mulches and shelterbelts to influence temperature, airflows, and humidity.
11) Adoption of water and soil conservation by countering erosion through influencing runoff and airflow.
12) Adoption of an agroecosystem oriented policy for marketing, extension, and education.
13) Selection and breeding of agricultural crops and livestock based on productivity and site-specific conditions.

References

Ali, Z. 1987. Replacement of maize grain with manure-molasses silage in broiler feed. M. S. Thesis. Department of Poultry Husbandry, University of Agriculture, Faisalabad.

Javaid, M. 1989. Fish yield studies with respect to various feeding and fertilizer regimes. Ph.D. Thesis. Department of Zoology, University of Agriculture, Faisalabad.

Nabi, G. 1985. Nitrogen fertilizer efficiency studies in rice. M.S. Thesis. Department of Soil Science, University of Agriculture, Faisalabad.

NARC (National Agricultural Research Center). 1988. Annual Report for 1987-88. Islamabad, Pakistan.

Zaka, M. A. 1986. Evaluation of an efficient source of nitrogen for rice. M.S. Thesis. Department of Soil Science, University of Agriculture, Faisalabad.

Zaki, Z. H. 1989. Effect of various combinations of organic and inorganic fertilizers on yield and chemical composition of rice. M. S. Thesis. Department of Soil Science, University of Agriculture, Faisalabad.