Sustainable Natural Farming System

Paedar Qudratti Nizam Kashatqari (PQNK)

August 2023

Introduction

Paedar Qudratti Nizam Kashatqari (pronounced picnic) means sustainable natural farming system in Urdu. Farmer Asif Sharif developed PQNK through first-hand experience on his land in the Indo-Gangetic Plains of Pakistan. Sharif calls PQNK 'Paradoxical Agriculture'. Sharif founded Pedaver, a company that works with thousands of farmers to disseminate PQNK and supply mechanised equipment and has contributed to the scholarship.[1] This briefing paper has been prepared by SRI-2030 with information and data provided by Pedaver Pvt. Ltd.

Sharif first identified that inundation, soil disturbance, and bare land are contrary to the natural processes of soil fertility and vegetation. As a result, he developed a raised bed planting system, with rice as the first crop as conventionally it is grown under flooded conditions. This was to demonstrate that water serves as a nutrient carrier, and only the water absorbed by the roots and transpired from the leaves is needed for plant development. At this time, Sharif learnt about the System of Rice Intensification (SRI) and gained insights into optimal plant population, i.e. row spacing and plant-to-plant distance. After achieving success by reducing rice plant density, the next objective was to maintain soil coverage. Rice crop residues were used for this purpose.

From this start, PQNK evolved into a system of cultivation for all crops and trees that combines SRI and Conservation Agriculture (CA), with natural farming as the overarching principle. The

[1] Abraham, B., Araya, H., Berhe, T. *et al.* The system of crop intensification: reports from the field on improving agricultural production, food security, and resilience to climate change for multiple crops. *Agric & Food Secur* **3**, 4 (2014). https://doi.org/10.1186/2048-7010-3-4.

PQNK approach replicates *natural* dynamics in *agricultural* production, like avoiding the use of synthetic inputs, keeping upland for vegetation and lowland for water supply, with drainage of excess water, as illustrated below.

Practices

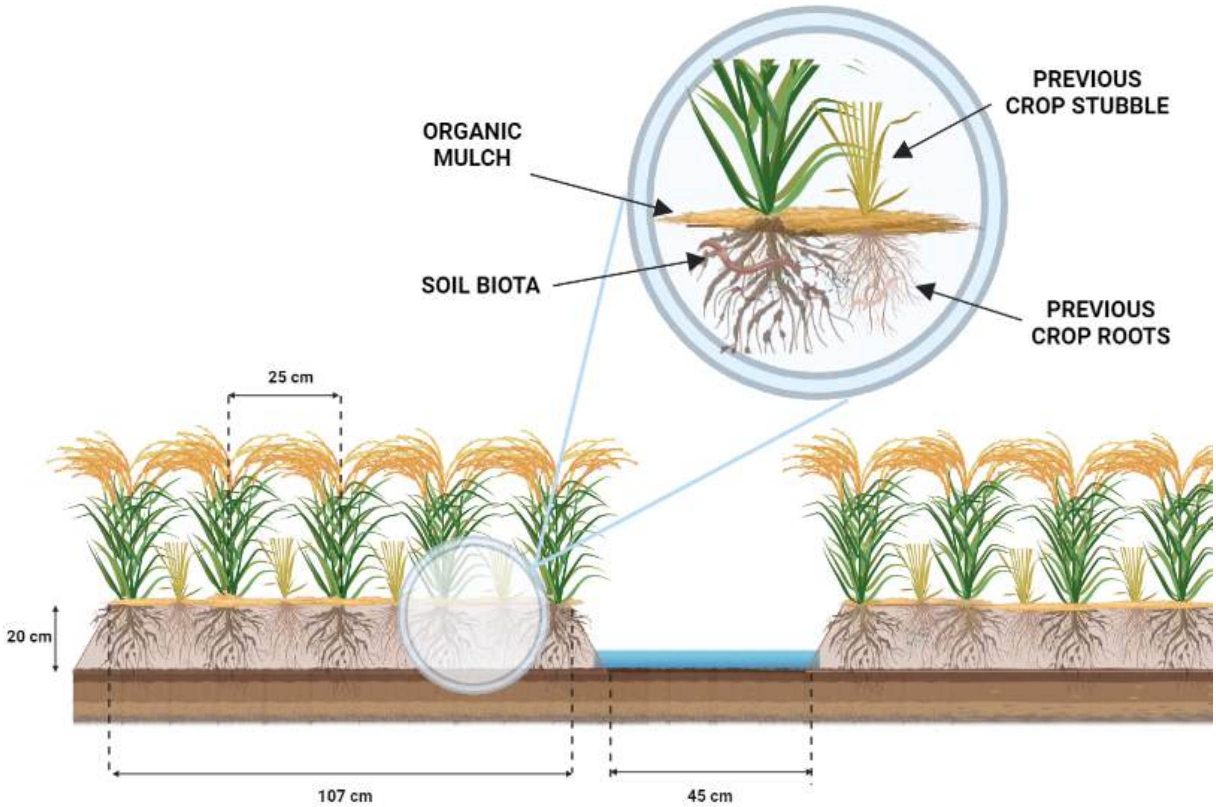
Under PQNK, crops are cultivated on permanent no-till raised beds that are formed on levelled, non-compacted land. The width of the beds is adapted to the size of the tractor and machinery wheels, so that the wheels drive through the furrows, and do not compact the beds. Beds are covered with organic mulch that can be locally procured by leaving crop residues on the field after harvesting, and by using cover crops between cash crops.

Irrigation is applied in the furrows between the beds. Nutrient uptake from the soil is optimised by plant spacing and hardpan breaking. The plant spacing also allows each plant to develop large canopies for catching sunlight and CO_2 from the atmosphere. The plant spacing is adapted to the requirements of each crop. Crop establishment can be done by transplanting or direct seeding. Direct planting is preferable, but if choosing to transplant the seedlings, one should do this early and carefully to bring minimal disturbance to the root systems. Farmers can use intercropping, relay cropping, and under-sowing to promote crop diversification. Introducing agroforestry practices such as alley cropping, where trees are placed within the agricultural field, is also a way to increase the available in-field biomass for mulching and to promote biodiversity while increasing farm production.

Raised beds

Growing crops on raised beds minimises soil disturbance, protects soil biota, improves soil structure, and promotes carbon sequestration. Also, with machines developed to the size of the raised beds, PQNK allows the large-scale implementation of no-till. Soil compaction is avoided as the tires of the heavy machinery drive in the furrows between the beds. This guarantees driving through the land without compromising the soil structure where crops are planted.

Designing the field with raised beds allows for furrow irrigation which improves water-use efficiency. For rice cultivation, which is traditionally implemented in flooded conditions, raised beds support SRI as the plants are never submerged. The bed topsoil is kept in aerobic condition, avoiding the degradation of plant roots, while also supporting more abundant beneficial soil organisms. This is particularly useful in areas prone to flooding as raised beds allow proper drainage of water, thereby protecting crops from suffocating.



Forming raised beds initially requires a significant expenditure of labour or capital (for mechanised construction) but leads to lower requirements for labour subsequently: man-hours per hectare is cut by 70% from 85 to 25, with a 90% reduction of water usage compared to flooding.

Organic mulch

The layer of organic mulch should be thick enough to cover the soil surface and prevent sunlight from reaching the soil. This inhibits weed germination, resulting in a non-chemical strategy for weed management. Maintaining permanent biomass cover on the soil surface also protects the land from overheating in direct sunlight, which adversely affects the soil biota. In fact, temperatures higher than 40°C kill almost all life in the soil. Organic mulch also reduces the force of winds and storms that erode the topsoil. Organic mulch applied as soil cover adds carbon and minerals to the soil system and supports the proliferation of soil microorganisms and mesofauna. Evaporation is reduced by biomass cover, conserving water. The retention of non-harvested crop biomass, rootstocks, and stubble in the field after harvesting conserves the stock of carbon in the soil. These materials, when they decompose, support the soil biota and improve soil structure. PQNK makes crop residues a valuable source of biomass as well as a tool for integrated weed and nutrient management, giving farmers an incentive not to burn them, which improves air quality and reduces greenhouse gas emissions.

Plant spacing

Increasing the spacing between plants, i.e., reducing plant density per m^2, should be done when soil is managed according to CA principles. Tillering crops naturally grow more profusely in the more fertile soil environment that is created by PQNK practices: more soil organic matter, more soil moisture, more biotic activity, and better soil structure. By allowing each plant to fully develop its root systems and its canopy, more nutrients are absorbed from the soil, and more carbon is stored in the soil, while photosynthesis is boosted. The result is an increase in plant productivity and a reduced seed consumption.

Diversification

Diversification increases biodiversity, land use efficiency and profitability, while enhancing carbon sequestration, especially when trees are included. There are many ways to achieve diversification such as cover crops between seasons and crop associations such as intercropping, alley cropping, relay cropping, and under-sowing are valuable options. As

raised beds need to be permanently covered with organic mulch, diversification provides the necessary biomass to keep the soil covered throughout the year. Crop diversification also reduces farmers' economic vulnerability and risks from individual crop failure.

Mechanisation

Pedaver has developed machinery for mechanically forming raised beds and furrows and for mechanised direct planting through heavy mulch with precise plant spacing. Transplanting of young single seedlings in permanent no-till raised beds with precise spacing is also possible as is forming the raised permanent beds while direct seeding in one single passage of the tractor. These machines allow the implementation of this system on larger farms. As noted, field design, with permanent raised beds and furrows for irrigation, allows tractor wheels to pass on the furrows without disturbing and compacting the cultivated land. The compaction of the furrows results in reduced water percolation during irrigation and increased water infiltration in the cultivated beds, conserving water. Innovations have focused mainly on the two most labour-intensive activities in the PQNK system: forming the no-till raised beds (a one-time operation) and (trans)planting of crops. Other operations, such as tilling the field and weeding, and spraying of agrochemicals, are eliminated because of the presence of permanent no-till raised beds and heavy mulch.

Results

The PQNK system has been adopted by tens of thousands of farmers in Pakistan because of the economic benefits it brings. Crop yields improve because of the better soil environment. Root systems and canopies get bigger with better plant spacing and because the broken hardpan gives space for the roots to expand. Overall, there is an increased availability of water and nutrients in the soil. Plants with improved phenotypic traits are not only more productive but also more resistant and resilient to the effects of extreme weather. PQNK practices result in a natural system of plant protection and nutrition that shields the plants against the attacks of pests and diseases and optimises the food uptake of the plants. This lowers the risks for farmers while reducing the costs of agrochemicals that also negatively affect life in the soil. The reduced labour of permanent no-till mulched raised beds further cuts production costs. Lower costs and better yield in quantity and quality result in greater profit for farmers.

The table below shows the results of an analysis carried out in 2020 by the Centre for Water Informatics and Technology at Lahore University of Management Sciences, comparing conventional and PQNK costs, translated into US dollars at a rate of US$0.0034 to PKR1.

In addition to the farmer benefits, PQNK offers positive environmental benefits. By reducing or elimination agrochemical inputs and avoiding tillage, PQNK minimises water and soil contamination while enhancing carbon sequestration and soil biological activities. Breaking the hardpan allows rain and irrigation water to seep back into the soil and replenish aquifers. With rice cultivation, PQNK reduces methane emissions by avoiding flooded conditions.

Cost-effectiveness of PQNK vs Conventional Agriculture – major crops

	Wheat		Sugarcane		Corn		Potatoes		Rice		Cotton	
P&L (US$/acre)	**Conv.**	**PQNK**	**Conv.**	**PQNK**	**Conv.**	**PQNK**	**Conv.**	**PQNK**	**Conv.**	**PQNK**	**Conv.**	**PQNK**
Revenue per acre	**524**	**598**	**952**	**1,190**	**707**	**707**	**816**	**816**	**789**	**789**	**612**	**734**
Production costs												
Land preparation	29	7	29	7	29	7	54	7	54	7	29	7
Seed	26	6	34	3	68	68	204	272	5	2	7	7
Sowing/planting	14	14	27	14	14	27	27	20	41	14	14	14
Fertiliser	55		88		88	17	88	7	55	7	55	
Pesticides			7		7	3	17		7		27	
Weedicides/hoeing	7		7		7		7		7	7	7	
Fungicides							14		7			
Harvesting exp.	27	27	109	136	27	27	34	34	27	27	27	27
Water exp.	27	7	41	7	34	9	17	7	41	7	27	7
Labour/supervision	34	34	34	34	34	34	34	34	34	34	34	34
Land rent	255	255	510	510	170	170	170	170	170	255	255	255
Total cost of production	**474**	**350**	**885**	**710**	**477**	**362**	**666**	**551**	**448**	**359**	**482**	**350**
Profit per acre	**50**	**249**	**67**	**480**	**230**	**345**	**150**	**265**	**341**	**430**	**130**	**384**
Profit PQNK v Conv. (%)		397%		617%		50%		77%		26%		196%