

Crop diversification through vegetable inter-cropping system

under Farmer FIRST Programme in Varanasi

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In recent decades, agricultural diversification has increasingly been considered as a panacea for the severe problems that have afflicted agriculture. Crop diversification including different cereal and horticultural crops in the cropping sequence can provide farmers with a better income. Therefore, a key step is to diversify the cereal-based production system through the inclusion of vegetable crops in the cropping sequence. Inclusion of vegetables in the major cropping systems will not only improve the availability of vegetables and help in food self-sufficiency but will also provide means to earn foreign exchange by exporting fresh vegetables and vegetable seeds. Moreover, these vegetable crops are suitable for production on small pieces of land and their inclusion in traditional cropping systems can improve the nutritional potential of the system.

Keywords: Crop diversification, Farmers FIRST Programme, Vegetable inter-cropping system

Farmers FIRST Programme

The Farmers FIRST Programme (FFP) project entitled “Intervention of Improved Agricultural Technologies for Livelihood and Nutritional Security Adhering Local Resources and Working Knowledge of the Farmers”, is to strengthen crop diversification by supplying quality inputs for nutritional and livelihood security. The interventions carried out by ICAR-Indian Institute of Vegetable Research was target specific and as per available resources and working knowledge of the people. Vegetable crops were used as major tools for crop diversification. The project was initiated by adopting 960 farm families in 6 villages namely, Paniyara, Dhanapur, Lashkariya, Upadhyapur, Baburam ka Pura and Rajapur in Araziline block of Varanasi district. Varanasi is located at an elevation of 80.71 m in Ganges valley in Eastern Uttar Pradesh. Humid sub-tropical climate with large variations between

summer and winter temperature is a common feature of Varanasi. Average annual rainfall is 1,110 mm, and the land is very fertile.

The dominant paddy-wheat cropping system of cultivation has led to serious economic, social and ecological problems such as deceleration in the productivity of groundwater resources and decline in soil fertility and increase in environmental pollution. Need was felt to diversify the traditionally grown less remunerative cropping system through suitable interventions of vegetable crops to achieve sustainable productivity, profitability and resource use efficiency. Following important interventions were introduced to promote crop diversification and increase cropping intensity.

Growing catch crop of vegetable pea and potato for higher income

Farmers of Paniyara, Upadhyapur, Laskaria, Dhanapur, Baburam ka Pura

and Rajapur village of Varanasi district follow rice-wheat cropping patterns. Availability of fast bulking, short-duration cultivars and flexibility in planting and harvesting time has made it possible to grow potatoes/peas in between principal cereals, rice and wheat. By adjusting planting schedules of different short duration early/late varieties of crops, better yield of each crop in rotation is possible. Therefore, ample scope exists for improving productivity in unit time with existing land resources by sandwiching potato/pea in rice-wheat system without affecting much of their yield. Short duration, early variety of Garden pea (Kashi Nandini) and fast bulking table potato variety Kufri Pukhraj and Kufri Khyati were taken as sandwich crop between rice-wheat cropping system for extra remuneration to the farmers.

Under conventional rice-wheat system, farmers grow long duration rice variety MTU-7029 in *khari*

followed by wheat. The normal time for transplanting rice was 2-3 week of July in these areas. The total duration of rice variety MTU-7029 is 150-165 days and the crop was harvested during the second fortnight of November to first week of December. The wheat crop was sown after harvest of rice crop. The delayed harvesting of wheat decreased the yield.

The FFP team suggested the farmer to grow medium duration rice variety HUR 917 which matures in 125-130 days in place of MTU-7029. 25 days old seedlings were transplanted in the field at spacing of 25 cm × 20 cm with 1-2 seedlings per hill during the second week of July. The normal cultural practices recommended for transplanted rice was adopted. The fertilizer was applied @ 120-60-60 kg N-P-K /ha. The rice crop (variety HUR-917) was harvested during 15-20 October.

After harvest of rice, well-sprouted potato tuber having size 40-50 g of potato cultivar Kufri Pukhraj and Kufri Khyati were planted during 25-30 October using seed rate of 30-34 q/ha at a uniform row distance of 60 cm and plant to plant spacing of 20 cm. Potato tubers were planted in furrows opened by small type of hoe and tubers were covered with 10-12 cm soil layer in the ridge and furrow system. Fertilizers were applied using the recommended dose of 150 kg N, 26.2 kg P and 83 kg K/ha for potato. Well decomposed FYM @ 15-20 t/ha was applied at the time of field preparation. In potato ½ dose of N and full dose of P and K were applied basal on the demarcated furrows

opened for potato planting and thoroughly mixed with soil before potato planting. The Remaining ½ of N of potato was top-dressed by the side of the crop rows after hoeing at 25 days after planting. Irrigation was provided as and when required and timely plant protection measures were taken. The other management practices were adopted as per the recommendations of the crop. The potato crop Kufri Pukhraj was harvested 65 days after planting in the last week of December and Kufri Khyati (Fig. 1) was harvested 75 days after planting during the first week of January.

Similarly, after harvesting of rice, pea crop was sown in lines with seed rate of 140-160 kg/ha at row to row spacing of 30 cm (Fig. 2). Seed treatment with *Rhizobium leguminosarum* culture was done @ 25 g/kg seed followed by *Trichoderma viride* @ 10 g/kg of seed before sowing. The depth of sowing was kept at 3-5 cm. After seed germination plant to plant spacing was maintained at 5-7 cm by thinning where plants were crowded. The crop was fertilized @ 60 kg P₂O₅, 40 kg K₂O and 25 kg N/ha as basal dose before sowing. The crop was protected from weed by applying one hand weeding at 20-25 days after sowing. Irrigation was given through sprinkler at the pre-flowering stage. Harvesting of well-filled tender pea pods was done twice at 62 and 73 days after sowing. After second harvesting the green plants of pea were ploughed in the soil by harrow plough before sowing of wheat.

After harvest of potato/pea, wheat

crop variety HD-2967 was sown with seed rate of 125 kg/ha in lines spaced at 20 cm. Three irrigation were given to wheat at monthly intervals coinciding with crown root initiation stage, jointing and milk stage. Fertilizer was applied @ 80-40-40 kg/ha of N-P-K. Full dose of P and K and half of N was applied as basal at the time of sowing and the rest half of N was top-dressed at CRI and boot (Ear initiation) stage. The wheat crop was harvested during second fortnight of April.

Yield: The yield of long duration rice variety MTU-7029 harvested during the second fortnight of November was 50.40 q/ha (Table 1). Yield obtained of medium duration rice variety HUR 917 was 42.45 q/ha. The early crop of Kufri Pukhraj produced a yield of 207 q/ha while Kufri Khyati yielded 222.5 q/ha. Green pod yield of Pea was 77.5 q/ha. Wheat crop yield was 34 q/ha when sown after Kufri Pukhraj while crop sown after Kufri Khyati yielded 30 q/ha. Wheat crop sown after harvest of long duration rice variety MTU-7029 in the first fortnight of December produced yield of 38 q/ha. The wheat crop sown after harvest of Rice crop HUR-917 at normal time in 20-25 November yielded 46 q/ha.

Economics: Sale price of rice HUR-917 was ₹ 1,750/q while MTU-7029 was ₹ 1,590/q. Sale price of wheat ₹ 1,825, potato (K. Pukhraj) ₹ 1,200/q and potato (K. Khyati) ₹ 1,100/q, pea green pod ₹ 1,500/q. The farmer who had grown catch crop of potato variety Kufri Pukhraj sacrificed ₹ 5,848/ha on rice and ₹ 7,360 on wheat while



Fig. 1. Demonstration of potato var. Kufri Khyati



Fig. 2. Demonstration of pea var. Kashi Nandini

Table 1. Effect of catch crop on Yield and economics of the cropping system

Cropping system	Rice yield (q/ha)	Catch crop yield (q/ha)	Wheat yield (q/ha)	System productivity (REY q/ha)	Net Income from the system (₹/ha)
Rice (MTU-7029)-Wheat	50.4	0	38	90.35	87,056
Rice (HUR-917) - Potato (K. PukJ) - Wheat	42.45	207	34	220.14	204,248
Rice (HUR-917) - Potato (K. Khyt) - wheat	42.56	222.5	30	213.96	193,430
Rice (HUR-917)-Pea-wheat	43.02	77.5	35.6	146.88	156,039
Rice (HUR-917)- wheat	42.89	0	46	91.26	98,698

growing Kufri Khyati sacrificed ₹ 5,848/ha on rice and ₹ 14,720/ha on wheat. Instead, he got an additional yield of potato variety Kufri Pukhraj and Kufri Khyati worth ₹ 128,400/ha and ₹ 124,750/ha respectively. Thus, farmers growing catch crop of potato variety kufri pukhraj and Kufri Khyati got an additional net income of ₹ 115,192/ha and ₹ 104,182/ha, respectively. Similarly, farmers who had grown Pea as catch crop sacrificed ₹ 5,848/ha on rice and ₹ 4,400 on wheat. Instead, he got an additional yield of pea worth ₹ 76,250. Thus, farmer growing catch crop of pea variety Kashi Nandini got an additional net income of ₹ 65,985.

Impact: The catch crop of potato and vegetable pea in between rice and wheat crop improved the overall productivity of the system by more than 140 and 61% respectively and improved the soil fertility and yield of wheat. Thus, by diversifying the existing cropping system with suitable crop and appropriate variety the farmer earned an extra income of ₹ 76,250-115,192 from one hectare in 65 days. Therefore, a medium maturing variety of rice, a fast bulking cultivar of potato or early maturing pea and late sown wheat will be more productive and remunerative in comparison to conventional rice-wheat system. The catch crop of potato and vegetable pea in between rice and wheat crop improved the soil fertility and yield of wheat and the farmer earned an extra income.

Double transplanting of rice for increasing cropping intensity and higher yield

For improved livelihoods and enhanced food security of rural farmers in the Eastern Indo-Gangetic Plains of India, double-transplanting technology of *kharif* rice was introduced in the rice-wheat cropping system. The main objective was to reduce the duration of land occupied by *kharif* rice so that an additional crop could be fit in before wheat crop to increase the productivity and profitability of the *kharif* rice-based cropping systems. Rice variety HUR-917 developed by BHU, Varanasi, is a medium duration (130-135 days), high yielding, aromatic, resistant to lodging and neck blast disease, having good grain quality with yield potential of 45-55 q/ha (Fig. 3). This variety was planted under double transplanting.

The rice nurseries for double-transplanting were seeded between May 15-20. *Kharif* rice in the traditional system of *kharif* rice-wheat system was seeded between June 20 to July 20 depending upon the arrival

of monsoon rain. The sowing dates in the nursery differed among the farmers and between years and therefore the range of sowing dates were provided. Under double transplanting, nursery bed was sown in an area of 75 m² with 3-5 kg seed. 25 days old seedlings were uprooted from nursery beds and transplanted into a small plot of 225 m² at 10×10 cm spacing with 8-10 seedlings per hill. This was the first transplanting. The ratio of area covered from nursery to the first transplanted plot was about 1:3. From the first transplanted plot, 30-35 day-old rice tillers were uprooted and transplanted for a second time into the main field. The tillers were transplanted at 20 × 15 cm row to row and plant to plant spacing with 2-3 tillers per hill. The split tillers planted in the main field covered 8-10 times the area of the first transplanted plot. The seedling/split tillers from 225 m² was sufficient for an area of 2500 m². In the case of the double-transplanting of rice, 30:15:15 kg/ha of NPK were applied for the first transplanting and 90:45:60 kg/ha of NPK were applied to the main field at the second transplanting. The mature rice was harvested 65-75 days after the second transplanting during first fortnight of October. Under the traditional system rice seedlings were transplanted @ 2-3 seedlings/hill at spacing of 25 × 20 cm. It took another 110-120 days for the crop to mature. The crop was harvested during first fortnight of November.

After the harvest of double transplanted rice, potato variety Kufri Pukhraj and Pea variety Kashi Udai was planted during October 18-22. The potato and pea crop were harvested at 70-75 days after sowing. Thereafter, wheat variety HD-2967 was sown with the seed rate of 125 kg/ha during last week of December to first week of January. Wheat crop was harvested during the second fortnight of April. Under conventional system, wheat crop was sown during



Fig. 3. Demonstration of paddy var. HUR-917

Table 2. Effect of double transplanting of rice on yield and economics of the cropping system

Cropping system	Rice yield (q/ha)	Wheat yield (q/ha)	Additional crop yield (q/ha)	System productivity (WEY q/ha)	Net Income (₹)
Rice (MTU-7029) - Wheat	49.5	37.3	0	80.07	82,337
Rice (HUR -917) - Wheat	42.6	47.4	0	84.21	97,701
DT Rice (MTU-7029)-Wheat	53.6	42.6	0	88.92	98,608
DT Rice (HUR -917)-Potato-Wheat	47.8	34.6	220.6	208.87	225,839
DT Rice (HUR-917)-Pea-Wheat	48.4	35.4	82.4	126.89	164,226

third to fourth week of November after HUR-917 and first fortnight of December after MTU-7029, with variety HD-2967 @ 80-90 kg/ha. 4-5 irrigations were applied in November while 3 irrigations were given to the late sown wheat.

Yield: The yield of long duration rice variety MTU-7029 harvested during the second fortnight of November under the traditional system was 49.5 q/ha (Table 2). Yield obtained of medium duration rice variety HUR 917 under the traditional system was 40.16 q/ha. Yield of the medium duration rice variety HUR 917 under double transplanting was 45.34 q/ha. The early crop of Kufri pukhraj produced a yield of 220.6 q/ha. The Green pod yield of pea was 82.4 quintals/ha. Wheat crop yield was 33.6 q/ha and 35.4 q/ha when sown after potato and pea respectively. The wheat crop sown after harvest of the long duration rice variety MTU-7029 in first fort night of December produced yield of 34.4 q/ha. Wheat crop sown after the harvest of Rice crop HUR-917 at normal time in 20-25 November yielded 43.5 q/ha.

Impact: Sale price of rice HUR-917 was ₹ 1,750/q while MTU-7029 was ₹ 1,590/q. Sale price of wheat ₹ 1,840/q, potato ₹ 1,200/q, pea green-pod ₹ 1,500/q. Double transplanting not only increased the yield of rice, but also made available enough time to grow a catch crop of short duration potato and pea without sacrificing the yield of wheat. The yield of rice, potato and pea was converted in terms of wheat equivalent yield. It is evident from Table 2 that Rice-potato-wheat produced highest wheat equivalent yield (WEY) of 208.87 q/ha followed by rice-pea-wheat (126.89 q/ha). Inclusion of catch crop increased the

overall productivity by 148 and 50.6% respectively over sole Rice-wheat system. The yield of double transplanted rice was 4-5 q/ha more than the normal transplanted crop. Farmers were encouraged to adopt the DT rice-pea/potato-wheat system by the overall increase in income from the system. The timely sowing of wheat allowed by the introduction of the new technology enabled the farmer to harvest higher yield of wheat and also reduced the effects of risk factors such as higher temperature at the maturity stage. These trials, assessed the feasibility and economic viability of double transplanting to enhance the productivity and profitability of the rice-based cropping system. Based on the initial observations, the participatory trials were extended to a greater number of farmers during next year i.e. 2018-19. Other farmers of the same and adjoining villages also introduced the double-transplanting technology after seeing the encouraging results from the fields of fellow farmers. The enhanced grain yield of rice crop and the higher income from the overall cropping system promoted by the double-transplanting technology, encouraged confidence among the farmers of the region. Introduction of the double-transplanting technology of rice has provided an effective way for better use of natural resources for enhanced and sustainable productivity and profitability of the system.

Table 3. Yield and economics of the rice-wheat system diversified through French bean

Cropping system	Rice yield (q/ha)	Rabi crop yield (q/ha)	System productivity REY(q/ha)	Net income (₹/ha)
Rice-Wheat	40.54	46.5	89.43	93,505
Rice-French bean	43.45	60	146.31	158,038

Sale price: Rice, ₹ 1,750/q; Wheat, ₹ 1,840/q; French bean pod, ₹ 3,000/q; REY, Rice equivalent yield.

Crop diversification

Farmers of Dhanapur, Laskaria and Paniyara are small and marginal with very small size land holdings. They mostly practice rice-wheat cropping system from which the income is very meager. In order to promote diversification and improve livelihood options of these small farmers, the vegetable French bean was introduced in these areas (Fig. 4). After harvesting of rice, vegetable French bean can be successfully grown during winter season in these areas. French bean variety Kashi Rajhans was developed by ICAR-IIVR, is a bush type, high yielding and resistant to collar rot and bacterial blight disease.

FFP team in order to promote multiple cropping patterns in the area organized training programme for the scientific cultivation of French bean. Farmers were trained to grow French bean during winter season. Seeds of French bean variety Kashi Rajhans were supplied to a group of 15 farmers to grow in *rabi* season. Farmers took up the cultivation of vegetable French bean for the first time in the area. The crop was raised in an area of one-acre which yielded 24.3 q of marketable French bean pods. The French bean was sold in the market at ₹ 30/kg and earned a net profit of ₹ 46,560 from land of 1 acre. Farmers are happy with the performance of French bean (Table 3).

Similarly, after harvest of rice crop, farmers in the Rajapur and Laskaria village were growing tomato. However, tomato growers were very much worried about leaf curl disease which decreases the yield drastically. Farmer adopts frequent chemical spray to control the leaf curl disease thus spending a lot of money on spraying chemicals. FFP team suggested farmers to grow leaf curl resistant tomato var. Kashi Aman (Fig. 5). This open pollinated variety



Fig. 4. Demonstration of French bean var. Kashi Rajhans



Fig. 5. Demonstration of tomato var. Kashi Aman

Table 4. Yield and economics of the rice-wheat system diversified through tomato

Cropping system	Rice Yield (q/ha)	Rabi crop yield (q/ha)	System productivity REY (q/ha)	Net Income (₹/ha)
Rice-Wheat	42.7	46.9	92.01	98,021
Rice-Tomato (K. Aman)	41.6	280.4	169.78	174,620
Rice-Tomato (local Var)	42.3	210.6	126.54	98,945

Sale price: Rice, ₹ 1750/q; Wheat, ₹ 1840/q; Tomato (K. Aman), ₹ 800/q; Tomato (Local), ₹ 700/q; REY, Rice equivalent yield.

Table 5. Yield and economics of the rice-wheat system diversified through chilli

Cropping system	Kharif crop Yield (q/ha)	Wheat yield (q/ha)	System productivity WEY (q/ha)	Net Income (₹/ha)
Rice-Wheat	41.6	47.2	86.77	96,648
Chilli-wheat	120.5	44.9	143.13	168,366

Sale price: Rice, ₹ 1750/q; Wheat, ₹ 1840/q; Chilli green, ₹ 1500/q; WEY, wheat equivalent yield.

of tomato was developed at IIVR, Varanasi and is resistant to ToLCV disease. Tomato variety Kashi Aman was demonstrated with 20 farmers for raising crop in an acre.

The crop was free from leaf curl disease and produce a bumper crop with a marketable yield of 113 q in one acre. The fruit size, colour and quality of Kashi Aman were very good having marketable importance. At the prevailed market price of ₹ 8/kg, farmers got a net return of ₹ 70,700 from an acre (Table 4). Performance of the new tomato variety was accepted and appreciated by the farmers.

Under upland and upper midland where there was no water stagnation

during *kharif*, green chilli-wheat system was promoted to diversify the system. Traditionally green chilli varieties are of 7-8 month duration, however chilly variety Kashi Anmol is short duration improved OP variety. Plants are determinate, dwarf (60-70 cm) with nodal pigmentation on stem and bear green attractive pendant fruits. First picking starts 55 days after transplanting; average green fruit yield of 125-150 q/ha in only 120 days of crop duration. After harvesting of chilli in end of December, wheat was sown with the recommended seed rate of 125 kg/ha in lines at 20 cm. The other cultural practices followed were as per the recommendations. Wheat crop was

harvested during the second fortnight of April and gave yield of 38.9 q/ha. Thus, inclusion of chilli crop in place of rice not only increased the overall productivity of the system by 65% but it also increased the net income by more than ₹ 71,000/ha (Table 5).

CONCLUSION

The objective was to diversify the existing cropping systems, through vegetable crops, economise resources and increase the efficiency of resources to increase the income of the farmers. In Rice-french bean, Rice-tomato and Chilli-wheat system, inclusion of vegetable increased the overall productivity and profitability of the system. These trials assessed the feasibility and economic viability of diversifying through vegetable crops to enhance the productivity and profitability of the cropping systems. Thus, by diversifying the existing cropping system with suitable crop and appropriate variety the farmer earned an extra income. Stability and profitability of a system depends not only on higher productivity but also on consistency in production of individual crops over the years.

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*Plant trees,
Conserve water,
Protect environment.*

