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Introduction of vegetables

for crop diversification among cereal growers in Indo-Gangetic Plains

Rajarshi Roy Burman*[1], Rahul Singh[2], Shailendra Sharma[3], D U M Rao[1], V K Singh[2] and A K Singh[3]

ICAR–Indian Agricultural Research Institute, New Delhi 110 012

Vegetable cultivation introduced as an experiment in farmers' fields on trial basis in 500 sq m plot has provided adequate evidence to show the remunerative potential of vegetable cultivation and a strong motivating force to attract and retain young farmers in agriculture. In the three ICAR-Farmer FIRST Programme (FFP) villages of Palwal district of Haryana, vegetable growers grew from 465 farmers in 2017-18 to 655 in 2018-19 and 797 in 2019-20, showing an increasing trend in growing number of farmers interested in vegetable cultivation. Acreage under vegetables in rice-wheat cropping Indo-Gangetic plains of three ICAR-FFP villages rose from 57.44 acres in 2017-18 to 89.02 acres in 2018-19 and 115.08 acres in 2019-20. Vegetable cultivation has proved to be a great catalyst in bringing about transformation in the villages as many resource-poor small and marginal farmers have started weaning away from cereal crop production and moving towards vegetable cultivation. This change in diversification will go a long way in changing the outlook of young farmers to continue to perceive farming as a remunerative profession. This will restore faith of farmers in remunerative potential of vegetable farming.

Key words: Farmer-Scientist Interface, Indo-Gangetic plains, Small and marginal farmers, Vegetable crops

THANKS to the great efforts of our farming community, agricultural scientists and extension personnel, India could achieve national food security. We are now surplus in cereal food grain production. The major provider contributing to India's food security is rice-wheat cropping system of the Indo-Gangetic Plains of Northern India, one of the largest alluvial plains in the world.

This article addresses the core issue of bringing about crop diversification among the small and marginal farmers of Indo-Gangetic plains by introducing vegetable crops for income augmentation and also for weaning cereal crop growers away from rice-wheat cropping system.

For ensuring income security in diversifying rice-wheat cropping systems to resource-poor small and marginal farmers promotions have been made for cereal food grains. However farmers continue to face problems of declining factor productivity and dwindling resource use efficiency and soil compaction problems.

Hence, introducing crop diversity with vegetables seemed to be the right answer. Introducing vegetable cultivation in small trial plots enhances the farmers' income and restore the confidence of rural youth in farming as a profitable and viable profession.

Hence, attempt was made under the ICAR-Farmer FIRST Programme (FFP) by introducing vegetables in city market for enhancing farmers' income. This experimentation in farmers' fields also helped in assessing the efficiency and advantage of improved vegetable varieties of vegetable crops developed by vegetable scientists of ICAR-Indian Agricultural Research Institute (IARI).

Technology Interventions

The farmer's experimentations were conducted in three project villages (Amarpur, Dadhota and Katesra) of ICAR- FFP in Palwal district of Haryana. In 2017-18, about 465 farmers were selected as farmer-experimenters for the purpose of accepting and growing improved vegetables crop varieties of IARI in their fields. As farmers were traditionally rice-wheat growers. Initial reluctance of growing vegetables was removed through counseling and appraising the small and marginal farmers on the relative economic advantage of vegetable crops in comparison to cereal food

grain crops. Initially, farmers were quite reluctant to try vegetable crops on their fields and the concerns raised were with respect to labour intensive nature of vegetable cultivation, and caste stigma in growing vegetables as it is believed that vegetable cultivation is not everyone's cup of tea but only particular caste groups (say, Saini) cultivate vegetables. Thus, farmers' concern was addressed first and resolved.

Four crops were introduced: Carrot, spinach (palak), mustard leafy vegetable (sarson sag) and brinjal. The latest improved varieties were Pusa Rudhira (carrot), Pusa All green (palak), Pusa sag 1 (mustard sag) and Pusa Shyamla (brinjal) (Fig. 1).

The first experiments in farmers' fields was were done in 2017-18 and continued for the next two years, 2018-19 and 2019-20. A plot size of 500 sq. m was taken for the experimentation. The crops were monitored regularly and the farmers were given training and advisory services. Economics of cultivation and sale proceeds were calculated to highlight the cost-benefit ratio.

Results

Vegetables, being fresh, are a daily necessity for consumers. Farmers growing vegetables need to put in hard work in terms of long hours of interculture operations, harvesting, grading, packaging and transporting to the nearby vegetable market. Since the small and marginal farmers have tried in a small plot of 500 sq. m (1/8 of on acre), they could get a feel of all the necessary hard work in vegetable cultivation. They have also experienced a sense of achievement because of cash returns every week They were earlier having an easy going laid-back life but with vegetables, they are always on their toes.

The results are presented under three sections

(*i*) Cost-benefit analysis of vegetable cultivation,

(*ii*) Comparative economics of diversified farming in Indo-Gangetic plains and

(*iii*) Impact of introducing vegetable cultivation among farmers on income augmentation as well as continued interest in continuing farming as their viable profession.

Cost-benefit analysis of vegetable cultivation

Brinjal: In order to introduce brinjal cultivation, an improved variety of brinjal, Pusa Shyamla, about 80 farmers of the three FFP villages were counselled and trained in 2017-18. They were encouraged to experiment diversification in their fields. For which, a small plot of 500

Pusa Shyamla

- Fruit being long, glossy and dark purple in colour has a good appeal to customers
- Brinjal plant being non-spiry with erect branches has a great appeal for farmers
- Fruit being long and weighing about 90 g each
- Ready for harvest in 75 days.

Pusa Rudhira

- Long deep red coloured Carrot with red coloured core are in great demand by customers
- Red carrots are very sweet with high ITS value (9.50 Brix).
- Can be sown in Sep-Oct and by mid-December harvested. Ready for harvest in 75 days.

Pusa All Green

- Ovate deep green leaves, uniformly tender and highly nutritive
- Can be grown early September and multi-cut 4-6 times
- High value early crop with highest remunerative / potential among all leafy vegetables.

Pusa Mustard Sag 1

- Long broad glabrous leaves in attractive green colour
- Round fleshy long and light green petiole
- First harvest can be after 35 days after sowing
- Can be multi-cut 3-4 times and very late in bolting (end of January)
- Rich in carotene, ascorbic acid (vitamin C) and nutritious.

Fig. 1. Farmers' farm experimentation in Amarpur, Dadhota and Katesra, Palwal District, Haryana under ICAR-FFP, 2017-2020.

Table 1. Performance of vegetable crops: Brinjal (Pusa Shyamla) in farmers' fields

Particular	2017-18	2018-19	2019-20
No. of farmers	80	120	150
Yield (q/500 m²)	14.76	15.04	15.23
Cost of Cultivation (₹/500 m²)	3,407.78	3,561.75	3,669.30
Market rate (₹/q)	795.00	850.00	880.00
Gross income (₹/500 m²)	11,734.20	12,784.00	13,402.40
Net income (₹/500 m²)	8,326.42	9,222.25	9,733.10
B:C Ratio	1:3.44	1:3.59	1:3.65

Table 2. Performance of vegetable crops: Carrot (Pusa Rudhira) in farmers' fields

Particular	2017-18	2018-19	2019-20
No. of farmers	150	190	250
Yield (q/500 m²)	9.27	9.66	10.02
Cost of Cultivation (₹/500 m²)	2,286.32	2,400.28	2,507.47
Market rate (₹/q)	850.00	885.00	910.00
Gross income (₹/500 m²)	7,879.50	8,549.10	9,118.20
Net income (₹/500 m²)	5,593.18	6,148.82	6,610.73
B:C Ratio	1:3.45	1:3.56	1:3.64

sq. m was on trial basis. The results are given in Table 1. The results depict number of farmers growing brinjal in three years. Economic parameters included yield. Costs, market price, gross income, net returns and cost-benefit ratio for brinjal cultivation in three years.

The mean yield of brinjal was about 14.76 from which each farmer could earn ₹ 8,326 from a small plot of 500 sq. m (one-eight of an acre). Cost-benefit ratio in the first year was 1:3.44. in the next year 2018-19, about 120 farmers cultivated brinjal and followed by 150 farmers in 2019-20.

Mean net incomes gradually increased from ₹ 8.32 thousand to 9.22 thousand and 97.3 thousand respectively from 500 sq. m in the three years.

As the market rate of brinjal increased marginally every year, the cost-benefit ratio in brinjal cultivation two rose from 3.44 to 3.59 and 3.65 respectively. The results were very encouraging for farmers and hence their interest in vegetable farming got enhanced.

Carrot: In the first year, about 150 farmers came forward to grow carrot. The results depicting number of farmers growing carrot in three years, are given in Table 2.

As farmers saw the results of experiments of carrot cultivation in farmers' fields in their own villages, they were move enthusiastic to learn to cultivate carrot. About 150 farmers started carrot (Pusa Rudhira) cultivation in 2017-18 on trial basis in 500 sq. m plots. They could harvest on average about 9.27 quintals in 500 sq. m from which each farmer has earned a mean net income of ₹ 5,593 from a carrot plot of 500 sq. m cost benefit ratio was up to 3.4. Moreover, the quality and colour of carrot was so good that they were getting best market rate. In the next year, 2018-19 about 190 farmers cultivated carrot followed by 250 farmers in 2019-20.

Mean net incomes from small plots of 500 sq. m rose from ₹ 5.59 thousand in first year to ₹ 6.14 thousand in second year and to ₹ 6.61 thousand in third year.

As the market rate for carrot increased every year, the cost-benefit ratio too gradually increased from 3.44 to 3.56 and to 3.64 respectively.

Farmers could now come to understand and appreciate the value of diversification as their real income increased and they could get monetary returns every week.

Palak: In the first year, about 155 farmers came forward to grow palak. The results depicting number of farmers growing palak in three years, are given in Table 3.

In winter, green leafy vegetables like palak and mustard sag are a craze among people. Palak (Pusa all green) with multiple cuts was grown by 155 farmers in the first year of introduction under ICAR-FFP in 2017-18 on trial basis in 500 sq. m plots from which each farmer could harvest 11.79 quintals per 500 sq. m. They earned on an average ₹ 3,359 from their small plots. The cost-benefit ratio come to be calculated at 1:3.48. The response from vegetable market was also very encouraging for farmers. In 2018-19, about 215 farmers grew palak followed by 240 farmers in 2019-20.

Mean net incomes from small plots of palak increased from ₹ 3.36 thousand in first year, to ₹ 3.96 thousand in 2018-19 and ₹ 4.59 thousand in 2019-20, respectively.

As the market rate of palak also increased, profitability of palak growers has also increased. Farmers' interest in vegetable cultivation gradually increased as they were now

Table 3. Performance of vegetable crops: Palak (Pusa All Green) in farmers' fields

Particular	2017-18	2018-19	2019-20
No. of farmers	155	215	240
Yield (q/500 m²)	11.79	12.20	12.69
Cost of Cultivation (₹/500 m²)	1,356.75	1,472.51	1,628.22
Market rate (₹/q)	400.00	445.00	490.00
Gross income (₹/500 m²)	4,716.00	5,429.00	6,218.10
Net income (₹/500 m²)	3,359.25	3,956.49	4,589.88
B:C Ratio	1:3.48	1:3.69	1:3.82

Table 4. Performance of vegetable crops: Mustard Sag (Pusa Sag 1) in farmers' fields

Particular	2017-18	2018-19	2019-20
No. of farmers	80	130	157
Yield (q/500 m²)	8.67	8.94	9.14
Cost of Cultivation (₹/500 m²)	931.38	1,002.05	1,064.00
Market rate (₹/q)	425.00	450.00	480.00
Gross income (₹/500 m²)	3,684.75	4,023.00	4,387.20
Net income (₹/500 m²)	2,753.37	3,020.95	3,323.20
B:C Ratio	1:3.96	1:4.02	1:4.12

more market-oriented and reaping regular weekly cash returns from vegetable market.

Mustard sag: In the first year, about 80 farmers came forward to grow mustard sag. The results depicting number of farmers growing mustard sag in three years, are given in Table 4.

Green leafy vegetable mustard sag (Pusa Sag 1) was a new introduction in the ICAR-FFP villages of Palwal district. Only 80 farmers evinced interest in growing mustard sag in 500 sq. m plots in 2017-18. Each farmer could get about 8.67 quintals from 500 sq. m (through 4 multiple cuts). Each farmer growing mustard sag could get on an average net income of ₹ 2,753 from 500 sq. m in 2017-18. Cost-benefit ratio was very encouraging as they were getting ₹ 3.96 from every rupee invested in mustard sag cultivation.

In 2017-18, 80 farmers grew mustard leafy vegetable but room picked up to 130 farmers in 2018-19 and to about 157 farmers in 2019-20.

As the market rate for mustard sag increased their net incomes too grew from ₹ 2.75 thousand to 3.02 thousand and 3.32 thousand, respectively in three years. Farmers could generate a good market for best mustard sag and their interest grew in cultivation of mustard sag.

Thus, all the vegetable farmers could witness profitability in growing vegetable, replacing rice-wheat cropping systems.

Comparative economics of diversification in Indo-Gangetic plains

Indo-Gangetic plains are characterized by large number of small and marginal farmers with meagre resources pursing rice-wheat cropping pattern. Here an attempt is made to show the relative economic advantage of introducing vegetable cultivation to replace rice-wheat cropping system.

Farmers of Indo-Gangetic plains have all along been growing rice and wheat and they continued to be poor and remained poorer due to several factors, such as (*i*) absence of any alternative farming system, (*ii*) low minimum support prices for both rice and wheat, (*iii*) both rice and wheat are easy crops to grow as farmers have a laid back attitude, and (*iv*) declining factor productivity and soil compaction problems associated with rice-wheat cropping systems.

Farmers were found eager to try vegetable cultivation on a small scale as vegetables cultivated for nearby city markets is much more remunerative than cereal crop cultivation. In spite of heavy work load and regular monitoring, supervision and management associated with vegetable cultivation, farmers were counselled to remove their initial hesitation and provided adequate training on vegetable cultivation.

In order to compare the economic advantage of vegetables over cereal crops, the results pertaining to crop duration, yield, cost of cultivation, gross income, net income, per day productivity and per day income were computed for rice, (Pusa Basmati 1509), wheat (HD 2967), brinjal (Pusa Shyamla), carrot (Pusa Rudhira), palak (all green) and mustard leafy vegetable (Pusa Sag 1). The results are presented in Table 5.

Yield and per day productivity

Per acre yields of rice and wheat (which are usually dried well) were in the range of about 15-19 quintals per acre. Vegetables being fresh, green and not dried weighed more at 123 quintals of brinjal, 81 quintals of carrot, 103 quintals of palak and 74 quintals of mustard sag.

Per day yield can easily be compared. While for rice and wheat the per day productivity was much lower at 12-13 kilograms. Vegetables were much superior in per day productivity with 63 kg of brinjal, 93 kg of carrot, 108 kg of palak and 123 kg of mustard sag.

Economic parameters

Net income of rice was ₹ 25.09 thousand and wheat was ₹ 30.94 thousand. But for brinjal, the net income per acre was ₹ 78.08 thousand rupees, carrot. 53.4, palak 37.15 and mustard sag ₹ 26.91 respectively.

Thus, it is clear that vegetable cultivation was much superior to cereals in terms of net returns gained per acre.

Cost-benefit ratios too showed a similar trend with cereals getting a benefit of 2.47 (rice) and 2.88 (wheat) for every rupee invested in cereal crop cultivation.

In case of vegetable cultivation, the benefits accrued were ₹ 3.65 (brinjal), 3.64 (carrot), 3.82 (palak) and ₹ 4.12 (mustard sag) for every single rupee invested in vegetable cultivation.

Much more interesting would be the income gained per day. In case of rice and wheat, the per day net income were between ₹ 214 to ₹ 216. In case of per day income of

Table 5. Comparative economics of vegetables and cereals in Indo-Gangetic plains

Crop (Varieties)	Rice PB 1509	Wheat HD 2967	Brinjal Pusa Shyamla	Carrot Pusa Rudhira	Palak All Green	Mustard Sag Pusa Sag 1
Duration (days)	115-120	143	190-200	85-90	90-100	60
Yield (q/acre)	15.05	19.42	123.30	81.08	102.72	74.00
Cost of cultivation (₹/acre)	17,045.73	16,439.06	29,698.91	20,295.15	13,178.65	8,611.87
Market rate (₹/q)	2,800.00	1m925.00	880.00	910.00	490.00	480.00
Gross Income (₹/acre)	42,140.00	37,383.50+47,383.50	1,08,504.00	73,782.80	50,332.80	35,520.00
Net Income (₹/acre)	25,094.27	30,944.44	78,805.09	53,487.65	37,154.15	26,908.13
B:C ratio	1:2.47	1:2.88	1:3.65	1:3.64	1:3.82	1:4.12
Per day Productivity (kg)	12.86	13.58	63.23	93.19	108.13	123.33
Per day Income (₹)	214.48	216.39	404.13	614.80	391.10	448.47

vegetables, the results are ₹ 404 (brinjal), ₹ 615 (carrot), ₹ 391 (palak) and ₹ 448 (mustard sag) respectively.

Farmers could clearly see for themselves the real economic advantage of vegetable cultivation. After seeing immediate cash return from vegetable sales, the interest of farmers has increased in vegetable cultivation. Initial hesitation and reluctance and concern of drudgery of heavy work load quickly disappeared. In the three consecutive years, the number of farmers growing vegetables and acreage have increased, the results of which will be presented and discerned in next section.

Impact of introduction of vegetables for diversifying rice-wheat cropping systems of Indo-Gangetic plains

Although rice-wheat growers of ICAR-FFP villages in Palwal district started quite reluctantly in growing vegetables for city marketing, they easily got motivated to continue vegetable farming because it found it to be quite remunerative. Vegetable farming is definitely superior in economic terms compared to cereal grain farming, which fact has been reiterated so well in the previous section.

Impact is measured in terms of outcomes especially in terms of spread of interest among the young farmers in vegetable cultivation, which is measured in terms of increase in number of farmers growing vegetables and also measured in terms of increase in acreage under vegetable cultivation in the project villages. As far as output and returns are concerned, they are already discussed in section I of the results. The results of impact are given in Table 6.

Increase in number of vegetable growers

As presented in Table 6, the number of farmers growing each of the four vegetables are shown and percent change in number of farmers are also shown. Acreage under four vegetables as also depicted.

Brinjal: In the first year (2017-18), 80 farmers started growing brinjal. In the second year (2018-19), the number rose to 120 and again up to 150 in the third year (2019-20). Percentage change in second year over first year was about 50% while it further increased to 87.5% in third year over first year. This percentage change has been observed to be gradual and calculated as farmers have also learnt risk management. The acreage under brinjal too showed such cautions trend in gradually increasing from 9.88 acres under brinjal in first year (2017-18) and rose up to 16.31 acre as (a percent increase of 65 over first year and again rose to 22.24 acres in (2019-20) percent increase of 128 over the first year (2017-18).

Carrot: The unique selling proposition of the new variety (Pusa Rudhira) the deep red carrot with red core and very sweet is the real season behind increase in number of carrot growers as well as acreage under carrot in the ICAR-FFP villages. In the first year, about 150 farmers started growing carrot and reaped good returns which motivated about 190 farmers to taken up carrot farming in the second year (2018-19), with a percent increase of 26.67 over first year. Again about 250 farmers evinced interest in carrot farming with percent increase of 66.67 over the first year. This increasing trend was also seen in acreage under carrot from 18.53 acres in first year (2017-18) which rose to 25.82 acres in second year (2018-19) with percent increase of 39.34 over first year. Again, acreage under carrot rose to 33.98 acres in 2019-20 with percent increase of 83.38 over the first year (2017-18).

The spread of carrot cultivation was quite processing in ICAR-FFP villages and it has amply proven that diversification in rice-wheat cropping systems of Indo-Gangetic plains can have a significant impact on farmers' interest, enthusiasm and profitability in vegetable cultivation. Indeed, farmers have returned back to farming as they saw a great ray of hope in remuner active potential of vegetable cultivation in Indo-Gangetic plains.

Palak: Increase in number of farmers growing palak was also witnessed from 155 farmers in first year (2017-18) to 215 in second year (2018-19) with a percent change of 18.71 over previous year. Again, the number of palak growers increased to 240 in third year (2019-20) with a percent change of 54.84 over the first year. This may be because of popular demand for palak among consumers and the multi-cut nature of palak variety- Pusa all green.

Similar, trend was also witnessed in acreage under palak which increased from 19.15 acres in 2017-18 to 29.22 acres, with a percent increase of 52.58 over first year. Again, the acreage under palak rose to 35.58 acres with percent change of 85.80 over first year.

The spread of palak cultivation among the ICAR-FFP villages has amply demonstrated the potential of diversification and its success in increased acreage under palak as well as enhanced interest in vegetable farming. Since this has been a

Table 6. Spread in number of vegetable farmers and in acreage of vegetables

Particular	Carrot			Palak			Mustard Sag			Brinjal		
Technologies intervention on (varieties)	Pusa Rudhira			Pusa All Green			Pusa Sag 1			Pusa Shyamla		
Years	2017-18	2018-19	2019-20	2017-18	2018-19	2019-20	2017-18	2018-19	2019-20	2017-18	2019-19	2019-20
Number of farmers	150	190	250	155	215	240	80	130	157	80	120	150
Per cent change	-	26.67	66.67	-	38.71	54.84	-	62.50	96.25	-	50.00	87.50
Total area covered in acres	18.53	25.82	33.98	19.15	29.22	35.58	9.88	17.67	23.28	9.88	16.31	22.24
Per cent change	-	39.34	83.38	-	52.58	85.80	-	79.49	135.63	-	65.08	125.10

farmers' experiment in ICAR-FFP villages, it has shown us the path towards making agriculture remunerative with vegetable cultivation and in attracting and retaining rural youth in farming profession.

Mustard Sag (Pusa Sag 1)

Although the farmers grow mustard sag in their backyards for house consumption, they were initially very reluctant to grow mustard sag for fear of getting market acceptance.

When they were counselled and convinced of the big round leaves of Pusa Sag 1, their interest grew gradually. Since it is a multi-cut variety and coves to flowering late by the end of January, the interest of farmers in growing mustard sag picked up slowly.

In the first year (2017-18), only 80 farmers come forward to grow mustard sag (which was quite low almost half in number compared to those who wanted to grow carrot or Palak). By next year mustard sag growers increased to 130 (with percent change of 62.5 over first year). Again, by third year, mustard sag growers increased to 157 (with percent increase of 96.28 over the year).

Acreage too showed similar trend. From 9.88 acres in first year (2017-18), it rose to 17.67 acres in 2018-19 (with percent increase of 29.49 over first year). Again, acreage rose to 23.28 acres (with percent change of 135.63 over first year). Thus, interest in mustard sag has increased gradually among the farmers of Indo-Gangetic plains.

Conclusion

As has already proved in the above three section of results, vegetable cultivation has proved to be a boon for farmers of ICAR-FFP village. Although initial hiccups were faced by the Farmer FIRST Programme scientists in counseling them to try on small plots, they have room understood the significance of diversification through experiential learning from farmer-experiment, frequent farmer scientist interface, market orientation, the relative economic advantage of vegetable farming. Their motivation and enthusiasm got boosted by economic motivation and remunerative potential of vegetable cultivation over cereal grain farming. The regular weakly cash returns from the markets through sale of high quality fresh vegetables was indeed the major catalyst in the diffusion of vegetable cultivation among the farmers over a period of three years and spread of acreage under vegetable farming.

Diversification through vegetable farming among rice-wheat growers of Indo-Gangetic plains can be a game changer among the large number of resource poor small and marginal farmers in the rice-wheat cropping systems of Indo-Gangetic plains.

[1]Principal Scientist, [2]Scientists, [3]Director.
*Corresponding author's email: burman_exth@mail. com