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Crop diversification and small holders: A micro-level evidence from Uttar Pradesh

S K DUBEY[1], A K SINGH[2], LAKHAN SINGH[3], ATAR SINGH[4], V K KANAUJIA[5] and BHUPENDRA KUMAR SINGH[6]

ICAR-Indian Agricultural Research Institute, New Delhi 110 012, India

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ABSTRACT

Survey was conducted in villages Digsara, Basirpur Mar, Pokhra and Bhavanipur under Jalalabad block of Kannauj districts to analyze the crop diversification systems during 2015–16. The major cropping systems included potato-groundnut/maize; paddy-potato-maize; paddy-wheat-green manuring; groundnut/maize-potato-maize; maize-mustard-maize and green manuring-early potato-wheat/seed potato. It was observed that summer groundnut was fast replaced by summer maize despite higher water requirement in summer maize (6–7 irrigation) than groundnut (3–4 irrigation) as farmers were getting higher yield (60–70 q/ha) in summer maize than groundnut (Yield: 37–40 q/ha).Summer groundnut was perceived more sustainable than summer maize as the underground water level was fast depleting in these area (declining at the rate of 2 ft. every year). Wheat crop was getting marginalized among small land holders. Major cropping systems followed by such farmers were fallow/dhaincha-potato-maize; maize-potato-maize and maize-early potato-wheat (very less area). Diversification with mixed cropping of minor vegetables likes coriander and *kharif* onion was also analyzed in these districts. Flower cultivation based crop diversification was documented in this study. It was found that flowers like rose, bela (jasmine) and mehndi (henna) were cultivated by the majority of farmers to address the industrial requirements in the district for making edible products of roses as well as perfumes. Potato+rose was the most frequently utilized cropping pattern as the fertilizer requirements of roses were being met from the residual nutrients of potato.The study recommends that the diversity in cropping systems among the small holders ought to be safeguarded and supported with the appropriate development interventions.

Key words: Crop diversification, Cereal based system, CDI and CPI, Vegetable based system

It has been a well-established fact that economic development, food security and poverty alleviation in developing countries has direct link with the performance of agricultural sector (Mugendi 2013, Fedoroff 2015). There are evidences that farmers producing cash crops in the developing world diversify their agricultural production systems to increase their incomes, improve and maintain food security and reduce vulnerability to poverty (Mulwa *et al*. 2017). A World Bank study conducted by Shawki *et al*. (2004) established that agriculture is increasingly being recognized as critical to reducing poverty in developing countries mostly because agricultural activities are rural in nature and poverty incidence is highly concentrated in rural space. The effect of how crop diversification impacts on two outcomes of climate smart agriculture; increased productivity (legume and cereal crop productivity) and enhanced resilience (household income, food security, and nutrition) in rural Zimbabwe (Makate *et al.* 2016). Dembele (2018) used cross-sectional data to analyse the factors that influenced diversification strategies among smallholder farmers in Southern Mali which showed that farmers were engage in four diversification strategies such as cotton and maize; cotton maize and millet; cotton maize, millet and sorghum and food crop production. In Indian context also, the impact of diversification of agriculture towards vegetables on farm income and employment clearly revealed that vegetable production is more profitable and labour-intensive, therefore it fits well in the small farm production systems (Joshi *et al*. 2006). Uttar Pradesh is most populous and fifth largest state of India, accounts for 6.88% of total area of the country. The distribution of size of holdings is very much uneven and out of total operational holdings of 23325 thousand ha, the marginal holding accounted for 79.45% followed by 13.02%, 5.71%, 1.71% and 0.11% of small, semi medium, medium and large holdings respectively. Under the given scenario, the farm

[1]Principal Scientist (skumar710@gmail.com), [4]Director (atarsingh_icar@yahoo.co),Agricultural Extension, ICAR-ATARI, Kanpur;[2]DDG (aksicar@gmail.com), Agricultural Extension, ICAR, KAB 1, New Delhi; [3]Director (akhanextn@gmail.com),Agricultural Extension, ICAR-ATARI, Pune; [5]Head (kvkkannauj@gmail.com), KVK Kannauj, Uttar Pradesh; [6]Associate Professor (bhupendra_dr@rediffmail.com), Plant Protection, CSAUAT, Kanpur.

income generated by those small holders becomes an area of interest and also it emanates the issues for investigation on various dimensions of crop diversifications among the small holder farmers. Against the above background, present study was conducted in the state of Uttar Pradesh to arrive at the empirical evidences to above research questions.

MATERIALS AND METHODS

The present study was carried out in Kannauj district of Uttar Pradesh during 2015–16. Two main reasons of large scale prevalence of small holders (about 75%) and mostly diversified cropping systems justified the purposive selection of the district. Further, the block Jalalabad was also purposively selected because of meeting the above criteria. Four villages, viz. Digsara, Basirpur Mar, Pokhra and Bhavanipur were randomly selected from this block. In every village, four focused group discussions were arranged, each comprised 30–35 farmers. Thus, 500 farmers from all the four villages were interacted. Major research variables included the documentation of crop inventory along with their productivity indexes and yield gap, diversity in the prevailing cropping systems, dynamics of crop preferences and the analysis of the strength, weaknesses, opportunity and threat of the diversified cropping system. The expected roles of different stakeholders were analyzed as perceived by the farmers. For analyzing the yield gap, Yield gap I and Yield gap II were computed (Jha *et al.* 2011). Similarly, crop productivity indeed (CPI) and crop diversification index (CDI) were also calculated (Sharda *et al.* 2012) as:

$$\text{Crop Productivity Index (CPI)} = 1/n \sum_{i=1}^{n} (y_i/Y_i)$$

where N, Total number of the crop cultivated by the farmer; y_i, Average yield of the i_{th} crop cultivated; Y_i, Yield of the i_{th} crop with standard package of practice of the highest yield in the area; CPI may value more than 0. Higher the CPI means closer to the maximum attainable yield.

$$\text{Crop Diversification Index (CDI)} = \sum_{i=1}^{n} P_i \log (1/P_i)$$

where N, Total number of the crop cultivated by the farmer; P_i, Proportion of i_{th} crop in comparison to total cropped area; CDI may have any value above 0. Higher the CDI means better crop diversification status.

For calculating the change in CDI, degree of newness of the cropping systems was taken into consideration. It implies that change in the CDI of the recent cropping system was compared with the CDI of oldest system with good acreage and in vogue.

The variables like profitability and employability in those systems were computed in terms of net return (₹/ ha/year) and mandays created (nos/year) respectively. The relative sustainability of the systems were ascertained on five points sustainability rating scores wherein 1 being the least sustainable and 5 being the most sustainable systems as perceived by the small holders. SWOT analysis and famers' perception were also captured using open-ended questions and based on the response, results were arranged rank-wise. A semi-structured interview was scheduled and supported with group discussion to elicit the information from the respondents. The collected data were analyzed using the simple statistics of average, percentage, rank, rank correlation (r) and coefficient of concordance (w) to draw meaningful conclusions**.**

RESULTS AND DISCUSSION

Major cropping systems and their evolution: Eleven (11) major cropping systems were prevailing in the study area. Three (3) systems, viz. potato-summer groundnut/maize, green manuring-early potato-seed potato and coriander + *kharif* onion/radish-spring onion-seed potato were very recently (last 5–6 years) originated. The system of green manuring-early potato-wheat was relatively older (8–9 years) in origin. Another system of potato-summer maize was still coexisting with the recent system. Further, it was found that cropping systems like paddy-potato-maize, *kharif* groundnut-potato-maize, maize-potato-maize and rose + potato were very old. It was also revealed from the analysis that two cropping systems, viz. paddy-wheat-green manuring and maize-mustard-maize had very lesser acreage (1–2%) in the study area and it was very older system (<11 years). The temporal analysis of the changed cropping system showed that, whereas in 2005–06, there was 14500 ha area under maize-potato-sunflower based cropping system which was shifted to maize-potato-maize system by the year 2015 (16750 ha area) mainly because of the fact that even sunflower was giving higher yield, processing of their heads was the major issue and farmers could not harvest the anticipated dividends. However, from the year 2014–15 onwards, maize became the questionable crop in the system as it required more water (6–7 irrigations) and even it resulted into the higher productivity (60–70 q/ha) and net return (₹ 55–60 tones/ha) it could not sustain and summer groundnut replaced it slowly. Summer groundnut required only 3–4 irrigations and even with lesser yield (37–40 q/ha), it is giving better economic dividends (₹ 65-70 tones/ha). Thus, currently, almost equal area (about 8000 ha) is under both potato-groundnut and potato-maize cropping system. However, as the profitability become the major concern for the small holders, summer maize again picked up since 2016 onwards and area under it (about 28 tones ha) is more than double of summer groundnut (9 tones ha) in the district. From the above analysis, it is also very interesting to note that the crop potato was never replaced by any other crop in the system. This may be mainly because of the fact that potato has established itself as the profitable commercial crop even though there is price fluctuation from year to year. Rose and potato coexisted mainly because of the fact that the higher nutrient doses in potato was supplementing the nutritional requirements of rose and thus making the system more profitable and sustainable.

Crop Productivity Index: Based on the CPI value of all the prevailing crops in the district, it could be observed (Table 1) that miner vegetables like coriander, spring onion

Table 1 Crop productivity and yield gap analysis of major crops

Category	Crops	Prevailing yields (q/ha)	CPI	Potential yield (q/ha)	Yield Gap I (%)	Yield Gap II (%)
Vegetable	Early potato	165.00	0.22 (VII)	250.00	34.00	25.00
	Seed potato	240.00	0.40 (II)	300.00	46.67	29.40
Oilseed	*Kharif* groundnut	14.00	0.11 (X)	40.00	65.00	45.00
	Summer groundnut	35.00	0.32 (IV)	55.00	36.37	19.90
	Kharif maize	36.00	0.15 (X)	80.00	55.00	45.00
Cereals	Summer maize	62.00	0.21 (VIII)	100.00	38.00	28.45
	Paddy (fine aromatic)	30.00	0.18 (IX)	55.00	45.45	35.25
	Wheat	31.00	0.28 (VI)	55.00	43.64	25.49
Flowers	Rose	250.00	0.31 (V)	400.00	37.50	27.75
	Jasmine	225.00	0.34 (III)	325.00	33.33	15.45
Miner vegetable	Coriander, spring onion, radish	150.00	0.59 (I)	160.00	06.25	03.49

Figures in parentheses indicate rank

and radish had highest CPI of 0.59 followed by seed potato (0.40), jasmine flower (0.34) and summer groundnut (0.32). The other crops, viz. rose, wheat, summer maize and early potato, the CPI ranged from 0.22–0.31. The lowest CPI was computed for *kharif* groundnut (0.11). The relative variation of the CPI score may be indicating the fact that farmers may be differentially adopting the technologies.

Yield gap analysis: The yield gap for all the prevailing crops was computed with respect to the potential yield (yield gap I) and demonstration (KVK FLD) yield (yield gap II) (Table 1). The highest yield gap I was recorded in case of *kharif* groundnut (65%) followed by *kharif* maize (55%), seed potato (46.67%) and fine aromatic paddy (45.45%). For other crops the yield gap I ranged from as low as 6.5% in case of miner vegetables to 38% for summer maize. Likewise, the yield gap II was highest for *kharif* groundnut and *kharif* maize (each 45%) followed by aromatic paddy (35.29%) and seed potato (29.40%). The relatively lower yield gap I is indicative of the fact that the crop varieties being used in that area were showing greater goodness-of-fit with the micro-farming characteristics. However, higher level of yield gap II is the matter of concern which only discloses the fact that new technologies, seeds, varieties etc. are not reaching to the farmers adequately and timely. This fact was also revealed when the farmers were asked to share their expectations from various stakeholders.

Crop diversification index: The results showed (Table 2) that mean CDI for the recent to very recent cropping systems which were evolved in last 5-6 years was 0.340. Four crops based systems, viz. coriander + *kharif* onion/ radish-spring onion-seed potato is gaining popularity among the small holder farmers of the area. Two crops based system was prevailing only in the form of potato-summer groundnut because of its two fold advantages of higher remunarativeness and perceived system sustainability. Potato- summer maize system is also coexisting but because of only two crops in the system, the CDI is only 1.98. There were three crops based cropping systems in the area which were very old (8–9 years) and thus their average CDI was 2.91. Similarly, for the least prevailing system (also <11 years old) the CDI was 0.283 and therefore, for calculating the change in CDI over the year, this system was ignored. Findings implied that small holders have established their own preferred cropping systems which met their requirements and other criteria of cost and profitability.

Profitability, employability and perceived sustainability of various systems: Altogether, a complex scenario emerged in the prevailing varied cropping systems, their profitability, employment generation and farmers' perception of the sustainability of these systems. Flower based potato intercrop raised the highest profitability (₹ 4.37 lakh/year/ha) which was closely followed by high density vegetable based diversified system (₹ 4.04 lakh/ year/ha) (Table 2). The employments generated by both the systems were in similar order (447 and 433 mandays/ year/ha) indicating thereby the ensured employment for more family member round the year. It is also evident that the reality of less profitability from the cereal based system is being recognized by the small holders, e.g. in case of paddy-wheat-green manuring, green manuring-early potato-wheat and maize-mustard-maize the profitability ranged from ₹ 1.29–1.93 lakh/year/ha with relatively lesser mandays generated. In most of the system, where potato was the main element and groundnut was taken either as *kharif* or summer crop, the profitability was more. Farmers were also asked to accord their preference rating of the sustainability of each system in terms of likely resource exhaustion and future continuance as perceived by them. All the input intensive systems were computed more profitable compared to others but their sustainability (on the basis of underground water exhaustion) ratings were lower (Table 2). Summer maize based cropping system emerged as less perceived sustainable system, whereas summer groundnut based system was felt comparatively more sustainable

Table 2 Crop diversification index and related indicators of major cropping systems

Cropping system	Age of the system (in years)	CDI	Change in CDI	Preference rating	Profitability (lac ₹/year/ha)	Employment (Mandays/year/ha)	Sustainability rating (out of 5)
Potato – Summer ground nut	Recent to very recent (5-6 years)	0.340	0.283 (old system) to 0.340 (very recent) 20.14% .... improvement in CDI	I	1.63 (IX)	307 (V)	4.10 (I)
Green manuring-Early potato-Seed potato				II	2.30 (V)	180 (XI)	3.40 (III)
Coriander+*khari* fonion/radish – spring onion-seed potato				III	4.04 (II)	433 (II)	4.00 (I)
Green manuring-Early potato-Wheat				IV	1.29 (XI)	213 (IX)	3.27 (IV)
Potato – Summer maize	Co-exiting (5-6 years)	1.98		III	2.20 (VI)	234 (VII)	3.12 (VII)
Paddy-Potato-Maize	Older system (8-9 years)	0.291		IV	2.32 (IV)	305 (VI)	3.00 (VIII)
Kharif Groundnut-Potato-Maize				V	2.80 (III)	411 (III)	3.21 (V)
Rose/Jasmin + Potato				IV	4.37 (I)	447 (I)	3.11 (VI)
Maize-Potato-Maize				IV	2.17 (VII)	310 (IV)	2.90 (IX)
Paddy-Wheat-Green manuring	Less prevailing (<11 years)	0.283		II	1.34 (X)	205 (X)	3.45 (II)
Maize-Mustard-Maize				I	1.93 (VIII)	231 (VIII)	3.10 (VII)
Rank correlation coefficient (r)						0.67*	
Coefficient of concordance (w)						0.355NS	

* P<0.0; NS, Non-significant; Letters in parentheses indicatethe ranking

but on profitability the trend was reversed. Interestingly, however, the input intensive vegetable based cropping system was also rated high from sustainability points of view which may be because of the fact that small holder farmers practicing such system may be maintaining the soil fertility through appropriate measures which was also affordable for them to do so.

As indicated in the first subhead that summer maize is having stiff competition with summer groundnut on irrigation requirements, but it has considerable profitability and ease of operations including now the use of mechanization in summer maize (even combine harvester is being used) which is strongly sustaining it in the system. Albeit, there was clear cut mismatch between the perceived profitability and sustainability of the system as indicated by the non-significant rank correlation value (0.355). However, in the evolution of the cropping systems as discussed above, farmers' more preference to substitute the input intensive crops by the less input demanding crops particularly in the potato based cropping system.

SWOT analysis of crop diversification: The perceived strength, weaknesses, opportunities and threats of the diversification of the cropping system in the study area was analyzed. The results indicate that providing climatic resilience and enhancing the farm income were major strength of crop diversification. However, it was also felt by the respondents that real potential of crop diversification was not tapped by them as they lacked in the know-how and do-how of the nutrient managements and the related packages of practices. This is the area which demands attention by the related KVKs or associated line departments.

Similarly, as the inclusion of more crops in the system involves more economic activities, the diversified system has the potential to ensure regular and meaningful employment to the farm family, thereby checking the rural migration. Similarly, processing and value addition was also seen as the future opportunity. Paradoxically, however, most of the farmers felt that inadequate market support, high perishability of the produces and the higher storage cost are some of the potential threats which may adversely affect the crop diversification among the small holders. The non-significant coefficient of concordance (w) revealed that farmers' understanding of strength, weaknesses, opportunities and threat for the diversified cropping system were not of the similar degree.

Farmers' expectations from the potential stakeholders: Based on the small holders' perception of strength, weaknesses, opportunities and threats, their view points were further elicited regarding the expected role of the various stakeholders who could be instrumental in making their diversified cropping system more efficient and profitable and also accord the relative preference ranking of those stakeholders as per their importance. It was revealed that middlemen (especially the aggregators, retailers and other marketeers) were least rated in order of importance. Even the respondents have lost confidence in the development officials of the related line departments (rank V) and they expressed that those officials need to repair their credibility and target vs achievements approach of the schemes and

activities need to be seriously looked into if they have to serve the small holders in more meaningful manners. Probably, that was the reasons that farmers expressed the need to consolidate themselves into formal institutions or interest groups (rank II). As the diversified system of cropping (esp. vegetable based) was more input intensive, they accorded first preference for input dealers in their area who could ensure the supply of quality inputs on time and at affordable price and therefore, the capacity building of the network of input dealers in the district were emphasized by the respondents.

Findings of the study confirmed that the small holders of the given micro-farming situations have diversified their cropping system to the maximum extent possible. Not only the systems were diversified, those were dynamic also and continuously evolving over the period of time. The higher level of profitability from those systems gives sufficient hints to the research, extension and development managers to support and sustain the system through knowledge and technology backstopping.

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