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Pushpa Singh
Scientist (Plant Protection), DRPCAU, Pusa, Samastipur, Bihar, India

KM Singh
Director, Extension Education, DRPCAU, Pusa, Samastipur, Bihar, India

Brajesh Shahi
Senior Scientist (Soil Science) and Nodal Officer (KVKs), DRPCAU, Pusa, Samastipur, Bihar, India

Correspondence
Pushpa Singh
Scientist (Plant Protection), DRPCAU, Pusa, Samastipur, Bihar, India

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Doubling income of cauliflower seed producer farmers of Vaishali district through pollination service by *Apis mellifera* colonies

Pushpa Singh, KM Singh and Brajesh Shahi

Abstract
A number of villages in Vaishali district have been engaged in growing cauliflower seeds and selling across the country with different brand names. The farmers traditionally produce seeds of local variety of early cauliflower *Brassica oleracea* under open field situation. Low seed yield and quality due to inadequate pollination is major problem of cauliflower seed producing farmers. Inadequate pollination in crops is due to several factors including lack of adequate number and diversity of pollinators. On farm trial was conducted by KVK, Vaishali, (DRPCAU, Pusa) on farmer's field at Hajipur, Lalganj, Mahua and Mahnar. Which are traditional producers of cauliflower seed. Cauliflower grown for seed production was covered by net of 100 m^2 area in the farmer's field and the control plot was open pollinated farmer field of the same farmer. During anthesis, two honeybee colonies of *A. mellifera* containing approximately 10,000 bees in a bee box were kept inside the net house to aid the pollination. More number of bees was found visiting the crop under net house condition 6.05, 5.35, 5.05, 6.08 bees/ plant at all locations. Bees in the open conditions were found to spend less time on flower as compared to the net house conditions. Planned honeybee pollination was found to result maximum impact on the seed production with 15.50-19.10 seeds/pod in net pollination as compared to 13.60-17.20 seeds/pod in open condition. Similarly, average 1000 seed wt. in net pollinated condition was 3.30-4.19gm whereas 3.00-3.97gm in open field condition, and the yield in net condition was in range 637-713 kg/ha as compared to 350-415kg/ha and additional income of 8 to10 lakh rupees/ha.
All possible ways of increasing the sustainable productivity and carrying capacity of the farming systems in order to improve the livelihoods and doubling income of marginal households should be explored and use of pollination service by Italian bee keeping can be one of the options.

Keywords: honey bee, *Apis mellifera*, cauliflower, pollination services, doubling income

Introduction
Hon'ble Prime Minister has declared goal of doubling Indian farmers' income by 2022. This is a herculean task whose gravity can be understood by the fact that Indian farmer's income has increased only 3 folds in the last 30 years (1983-2013) on constant prices. This goal of doubling farmer's income has met with response varying from doomed failure to optimism.
There is absence of adequate information on farmers' income to really know its adequacy, fluctuations and growth in farmers' income, thereby making it difficult to know how various factors affects farmers' income. A NITI Ayog study (Chand *et al*., 2015) provides estimates of total and per cultivator farm income for 1983-84 to 2011-12 and identifies sources of growth in farm income. They reported that increase in productivity, rise in real farm prices and shift of labour force from agriculture are the important determinants of growth in farm income. The study also identified agrarian distress as farmers suicides, increased when growth in farm income was low and the same went down when farmers income experienced high growth rate. The study noted that the income earned from agriculture was not adequate to keep 53 percent households out of poverty, which operated on less than 0.63 hectare of land holdings. Two national level surveys of NSSO titled Situation Assessment Survey of farmers in 2003

(59th round) and Situation Assessment Survey of Agricultural Households (SAS) in 2013 (70th Round) provided estimates of farmers income from various sources including agriculture. As per SAS for 2012-13, the average annual income from farm and non-farm source was Rs. 77,112 of which sixty percent was from farm activities i.e., cultivation and farming of animals and rest 40 percent from non- farm sources like wages, salary and non-farm business. In absolute terms, cultivation generated 36,938 and livestock provided Rs. 9,176 per agricultural household.

Approximately 80% of the low-income marginal farmers are concentrated in eastern (58%) and western (21%) regions that have been lagging behind in agricultural development on account of several factors, such as under-investment in agricultural research, poor infrastructure (electricity, markets, roads), under-development of institutions (credit, extension, insurance) and a lack of complementarily among these. To achieve this ambitious goal of doubling farmers income would require targeted interventions and identification of strategies that are associated with higher income and the marginal farmers, especially those in eastern and western states, should be at the forefront of the income-enhancing strategy as well as the strategy of bringing green revolution in eastern India (BGREI) need to be redesigned (Birthal *et al*. 2017).

Agriculture is the basis of the livelihood of over 80 percent of the rural population in Bihar (Pandey *et al.*, 2012) [14]. However, most of the farmers are marginal or small land-holding families, cultivating less than one hectare of land**.** The small and marginal farmers of Bihar are increasingly taking up vegetable cultivation to improve their income (Bharat *et al*., 2014). In Vaishali district of Bihar the vegetable based farming system among different category of farmers is most prevalent (Suman, 2014) [12]. The farmers here traditionally produce seeds of local variety of early cauliflower *Brassica oleracea* under open field situation. Low seed yield and quality due to inadequate pollination is major problem of cauliflower seed producing farmers. Inadequate pollination in crops is due to several factors and the most important of which includes lack of adequate number and diversity of pollinators. All possible ways of increasing the sustainable productivity and carrying capacity of the farming systems in order to improve the livelihoods of marginal households should be explored (Partap and Pratap 1997 & 2000) [9, 10]. Amongst several factors attributing to increase productivity, the most important of which include the number of bee pollinators. Research has shown that pollination by honey bee's increases fruit set, enhances fruit quality and reduces fruit drop in apple (Dutta and Verma, 1987) [7], peach, plum, citrus, kiwi and strawberry. Bee pollination does not only increase the fruit set but also reduced fruit drop in apple, peach, plum and citrus. The experiment conducted AICP on Honeybee Research and Training (ICAR) at various agricultural university have shown that honeybee pollination enhanced seed production and quality of seed in various vegetable crops such as cabbage, cauliflower, radish, broad leaf mustard and lettuce (Verma and Pratap,1994) [13]. The global population of managed honey bee hives has increased by 45 percent during the last half century (Gallai *et al*., 2009) [8] but with the spread of intensive agriculture capacity to provide sufficient pollination services may be stressed, and more pronouncedly in the developing world than in the developed world. Bee colonies can be most effectively utilized in not only the production of cauliflower seed but also improve seed qualitatively, thereby improving farmers income

Cross pollination of entomophilous crops by honeybees is considered as one of the effective and cheapest method for triggering the crop yield both qualitatively and quantitatively. It has been estimated that the value of additional yield obtained due to bee pollination 15-20 times more than the value of all the hive products put together and the total value of pollination services rendered by all insects globally comes in excess of 100 billion US dollars annually. In India 50 million hectares of land is under bee dependent but tapping only about 1/4th of the available floral resources of the country and estimated losses in due to absence of bee pollination has been estimated to be around Rs.10,000 to Rs.55,000 per hectare in some crops. We need to increase our understanding of pollination as a critical element in the world's food supply, and pay greater attention to the maintaining of pollination services in agricultural management. Thus, there is a need to ensure pollination by conserving the pollinators and attracting them towards the crop fields. This can be achieved only through planned honeybee pollination, owing to the fact that honeybees are the only pollinators which we can be managed. Pollination by insects is inevitable for *Brassica*, since they are generally incompatible (Sihag, 2001) [11] and the pollen is heavier and sticky, which is unable to be easily wind borne. Even though, the bees are reported as marvelously coevolved pollen transferring devices for *Brassicas*, the pollination potential and economic importance of the effect of honeybees on these vegetables still needs to be established. There are reports that placing of 3-5 bee colonies of *Apis ceranaindica/* acre of crop have increased the seed yield in sunflower by 79%, mustard by 55%, niger by 33%, sesame by 15%, safflower by 64%, cotton by 18%, litchi by 20%, coconut by 40%, and gourd crops by 20%. Bees are the most effective pollinators of crops and natural flora and are reported to pollinate over 70 percent of the world's cultivated crops. It has also been reported that about 15 percent of the principal crops are pollinated by domestic bees, while at least 80 percent are pollinated by the wild bees (Kenmore and krell, 1998).

Bihar Agriculture: An Overview

The eastern states particularly Bihar has the large unharnessed potential. It is considered destination for second Green Revolution in the country. Several reports including the National Farmers Commission have emphasized the need for accelerated development of agriculture in eastern India for securing food security of the country. Dr. A.P.J. Abdul Kalam, the then President of India has described Agriculture as Core Competence of Bihar. Fertile Gangetic alluvial soil, abundant water resources, particularly ground water resources, forms the basis of agriculture in Bihar, where farmers grow a variety of crops like food-grains, oilseeds, pulses, fibre crops, sugarcane, fruits, vegetables and other crops.

Land Utilization (Lakh Hectare)

Item	Area
Total geographical area	93.60
Forest	6.22
Land put to nonagricultural uses	17.03
Barren & uncultivated land	4.31
Permanent pastures	0.16
Land under miscellaneous trees and groves	2.44
Culturable wasteland	0.45
Current fallow land	7.81
Other fallow land	1.21
Net sown area	53.95
Gross cropped Area	76.46

(* 2011-12, Source-Directorate of statistics)

Agriculture and allied sector contributes 18.9 percent of the GSDP. The rate of growth of Agriculture and allied sector has been 5.4 percent during 2005-10 and 3.7 percent during 2010-14. Farm holdings are small and scattered. There are about 1.61 crore farm holdings of which 91 percent is marginal. The water area of Bihar constitutes about 3.9 percent of the total geographical area. In 2004-05, the production of fish in Bihar was 2.67 lakh tonnes. The production grew continuously thereafter and reached the peak level of 4.32 lakh tonnes in 2013-14. Bihar is a major fruit and vegetable growing state. Total vegetable production in Bihar is about 156.29 lakh tonnes. Potato, Onion, Tomato, Brinjal, Okra and Cauliflower is the major vegetable crop of the state. It is also known for its litchi and mango. The four most important fruit crops are mango, guava, litchi and banana. In 2013-14, their production levels were mango (12.74 lakh tonnes), guava (2.39 lakh tonnes), litchi (2.34 lakh tonnes) and banana (14.36 lakh tonnes). Flower production in Bihar has increased recently, providing immense opportunity of employment and income in rural areas of Bihar. In 2013-14, about 99 tonnes of rose, 6799 tonnes of marigold, 317 tonnes of jasmine (Bela) and 536 tonnes of the tuberose were produced in Bihar.

The critical points of Bihar Agriculture is that 60% farmers hold less than 1ha land, 38% farmers hold less than 0.5 ha land but 68% population derive livelihood from agriculture. There is very Low level of mechanization & local level processing at village and state level too. Only 60% area is irrigated and major irrigation from ground water is by 100% diesel engine powered by use of inefficient centrifugal pumps with efficiency around 30-40%.

Material and Methods

Bee keeping has been one of the rural enterprises in a small pocket of Goraul block in large scale but with the intervention through training and demonstration by K.V.K. there has been tremendously increase in number, colonies production and income of the farmers as evident from the table 1. The intervention of this on farm Trial was planned to coordinate two enterprise of beekeeping and cauliflower seed production to double the income of farmers.

Table 1: Bee-keeping status in the district Vaishali

Particulars	Year				
	2007-08	2008-09	2009-10	2010-11	2011-12
Progressive no. of beekeepers	35	94	188	265	295
No. of colonies established	1050	2820	6580	7950	8850
Total Honey production (in ton) @ 40 kg/box	42	112.8	263.2	318	354
Income from sale of Honey (Rs. in Lacs @ 70/kg.	29.4	78.96	184.24	222.6	247.80
Number of bee colony (5 frame) sold per year	175	470	940	1325	1975
Income from sale of colony (in Rs. lacs @ 1600/colony)	2.8	7.52	15.04	21.2	31.60
Total income from Beekeeping (Rs. in lacs)	32.2	86.48	199.28	240.38	279.4

On farm trial was conducted by KVK, Vaishali, (DRPCAU, Pusa) in farmer's field at three Blocks, namely, Hajipur, Lalganj and Mahua which are traditional producers of cauliflower seed and beekeeping was gaining popularity. Cauliflower was grown for seed production following the usual agronomic practices followed by farmers. Cauliflower grown for seed production was covered by net of 100 m2 area in the farmer's field and the control plot was open pollinated farmer field of the same farmer. During anthesis, two honeybee colonies of *A. mellifera* containing approximately 10,000 bees in a bee box were kept inside the net house to aid the pollination. The honeybees (*A. mellifera* F.) were reared in Langstroth boxes of size 50x40x30 cm at the KVK demonstration unit. Foraging activities like, time spent by a bee per flower and number of flowers visited by a bee per minute were observed by using a stop watch. The observations were made for five days when the plant was at full bloom, pollination activities were noticed at 12 Noon when there is bright sun shine and maximum bee activity. At harvest time, twenty randomly selected plants were tagged and number of pods per plant, number of seeds per pod and 1000 seed weight (5 replications) were recorded. The total seed yield in the net house area of 100 m2 was also calculated and yield/ha was calculated. Similar observations were made in open-pollinated field.

Result and Discussion

The pollination behavior of *A. mellifera* was observed as described in Table 2. The average number of foraging bees/plant was found highest at Hajipur (6.05) followed by Lalganj (5.05) and Mahua (5.35) in net house condition, while it was 1.65, 1.30 and 1.25 at the three location respectively in open condition. Similarly the average time spent by bees per flower was 6.45, 6.92 and 5.54 seconds in net and 6.50, 6.82 and 5.39 seconds in open pollination at all three locations respectively. The average number of flowers visited per minute revealed higher values for open pollination with 9.65, 8.40 and 6.45 flowers visited per minute followed 8.15, 9.40 and 6.45 in net pollinated condition (Table 2). There was marked improvement in seed production and overall seed quality and vigor in net honeybee pollination. In 2010-11, under net honeybee pollination produced 52.80 pods per panicle as against 46.20 pods in open pollinated crop, with an increase in pod setting to a tune of 12.50%. There was an increase of 12.25% in seeds per pod in planned honeybee pollinated crops and 9.09% increase in thousand seed weight resulting in 28.14% increase in seed yield at Hajipur, whereas, in Lalganj plants produced 42.70 pods per panicle in net honey bee plots as against 36.40 pods open pollination. An increase of 10.88% seeds per pod was observed in honeybee introduced crops resulted in 11.88% increase in seed yield (Table 3). At Mahua there was 42.30 pods per panicle in net where as it was 35.70 pods in the open plot. The thousand seed weight was found to be 4.15 and 3.97 g in the planned honeybee and natural pollinated crops, respectively. In second year of trial i.e., 2011-12 similar results were observed, net honeybee pollination increased the number of pods per panicle, seed per pod and thousand seed weight as compared to open pollinated crops. The seed yield of was 620.50 kg/ ha in honeybee pollinated crop, while open pollinated crop yielded 439.30 kg/ha. The seed yield was also high up to 574.00 kg/ha in honeybee pollinated crop. Whereas it was 372.00 kg/ ha in the open pollinated crop at Lalganj. The increase in pods per panicle and seeds per pod was found 14.25 and 11.08%, respectively in honeybee introduced crop over open pollinated crop at Mahua with the yield of

637Kg/ha in net honeybees pollinated crop. Pollination behavior of *A. mellifera* was studied to observe its behavior resulting in change in quality and quantity of seed produced, this study was done for five days when the crop was at the full bloom and at 12 Noon when bee activity is quite high. As the bee colony was placed inside the net house, their numbers inside the net house was found to be higher resulting in higher number of pods per panicle and higher seeds per pod and overall seed yield in the net house when compared to open field conditions. Bees in open conditions spent less time on flowers as compared to the net condition, which may be due to closed and less flower availability. Similar result were reported in case *A. mellifera* which spend less time in broccoli flowers kept in open than in caged conditions. There was increase pod setting, seed setting and the seed yield at all the three locations. Abrol (2007) [1] had reported that insect pollinators not only enhance the yield of the crop but also contribute uniform and early pod setting. The thousand seed weight was also reported to be 3.64g and 3.21g in honeybee pollinated and natural crop, respectively (Devkota *et al*., 2003) [5].

Table 2: Pollination pattern of *A. mellifera* at different locations

Observations	Hajipur		Lalganj		Mahua	
	Under Net	Open	Under Net	Open	Under Net	Open
Average no. of bees/ plant	5.05 (1.05)	1.45 (0.88)	5.25 (1.05)	1.30 (0.86)	5.35 (1.09)	1.25 (0.85)
Average time spent/ flower (sec)	5.45 (0.80)	5.65 (0.81)	5.92 (0.82)	5.82 (0.81)	4.54 (0.98)	4.39 (0.78)
Average No. of flowers visited/min	7.25 (1.40)	7.40 (1.64)	5.45 (1.57)	5.55 (1.47)	7.40 (1.31)	7.65 (1.35)

Note: Mean of 5 days observations and fig. in parenthesis are SD values

Table 3: Effect of Net Pollination on Seed Production of Cauliflower

Location	Parameters	I st Year			II nd Year		
		OP	NP	% Increase	OP	NP	% Increase
Hajipur	sPods/panicle	46.20(10.13)	52.80(6.01)	12.50	48.20(8.59)	55.10(4.78)	12.52
	Seeds/pod	13.60(4.11)	15.50(2.11)	12.25	13.20(4.32)	16.70(1.98)	20.96
	1000 seed wt.	3.00(0.07)	3.30(0.07)	9.09	3.04(0.06)	3.36(0.04)	9.52
	Seed yield	416.80	580.00	28.14	439.30	620.50	29.20
Lalganj	Pods/panicle	36.40(7.92)	42.70(4.22)	14.75	40.20(3.91)	45.80(3.43)	12.23
	Seeds/pod	17.20(4.94)	19.30(2.79)	10.88	16.70(3.33)	19.10(3.16)	12.57
	1000 seed wt.	3.08(0.04)	3.14(0.03)	5.26	3.00(0.11)	3.11(0.07)	9.91
	Seed yield	327.00	534.00	11.88	372.00	574.85	12.14
Mahua	Pods/panicle	35.70(7.38)	42.30(4.34)	15.60	39.10(3.23)	45.60(4.38)	14.25
	Seeds/pod	16.00(3.98)	17.94(2.82)	10.81	15.25(3.75)	17.15(2.37)	11.08
	1000 seed wt.	3.97(0.10)	4.15(0.09)	4.34	3.88(0.15)	4.19(0.07)	7.40
	Seed yield	379.00	534.00	20.00	415.00	637.00	23.53

Table 4: Increase in yield and economics

Location	Yield (Kg/ha)		Additional Yield (Kg/ha)	Income Increase @ 8000/Kg
	Open Pollinated	Net Pollinated		
Hajipur	439.30	620.50	181.20	14,49,600.00
Lalganj	372.50	574.56	202.06	16,16,480.00
Mahua	415.00	637.30	222.30	17,78,400.00

Conclusion

This study result clearly indicates the importance of pollination services of honey bees and the role bee colonies can play in improving the quality and quantity of seed production of cauliflower in particular and other crops in general.

India's net cropped area has been stagnating for quite some time, which clearly implies limited scope for income growth through area expansion. The recourse, thus, needs to be with prospects for income growth by raising cropping intensity, reducing inefficiency in production, and diversifying production portfolio towards high-value crops and animal production. The expansion in agriculture needs to exploit the intensive margin a lot more that can be done by improving farmers' access to reliable irrigation facilities and seeds of short-duration high-yielding crops/varieties, and mechanization of agricultural operations.

The constraint due to ubiquitous smallholdings to be mitigated, strategies for broad-based growth of rural nonfarm sector would be also required. Agriculture generates considerable surplus to attract investment in local manufacturing of value-added products; and hence there is considerable scope for rural industrialization. The expanding rural nonfarm sector will create multiplier effect through additional opportunities in ancillary industries related to inputs, equipment, machines and support services, and will generate income for investment in farm production. Investment in human capital or skill development and value chains will be a key to rural industrialization.

Doubling farmers' income in a short period is a challenge, but not insurmountable if the stakeholders follow a comprehensive, multi-pronged and targeted approach encompassing income opportunities and their enabling conditions including investment in agricultural research and infrastructure, and development of institutions and human resources.

References

1. Abrol DP. Honey bees and rape seed: A pollinator plant interaction. Advances in Botanical Research. 2007; 45:337-7.
2. Abrol DP. Pollination biology: Biodiversity conservation and agricultural production. Springer Dordrecht Heidelberg London, New York, 2012.
3. Aizen MA, Harder LD. The Global Stock of Domesticated Honey Bees is Growing Slower than Agricultural Demand for Pollination. Current Biology. 2009; 19:915-8.
4. Bharati RC, Singh KM, Chandra N, Singh AK. Economic Condition of Eastern Region of India-A Statistical Evaluation. Journal of Agri Search. 2014; 1(3):173-9.
5. Devkota FR, Upreti G, Thapa RB, Shakya SM, Pratap U. Impact of Honeybee Pollination on Productivity and Quality of Broccoli Seed under Chitwan Condition.

Journal of Institute of Agriculture and Animal Sciences. 2003; 24:85-9.
6. Devkota FR, Tapa RB. Forage preference of *Apis mellifera L*. to broccoli under caged and open conditions in Chitwan. Journal of Institute of Agriculture and Animal Sciences. 2005; 26:167-8.
7. Dutta PC, Verma LR. Role of insect pollinators on yield and quality of apple fruit. Indian Journal of Horticulture. 1987; 44:274-9.
8. Gallai N, Salles J, Settele J, Vaissière BE. Economic valuation of the vulnerability of world agriculture confronted with pollinator decline. Ecological Economics. 2009; 68:810-21.
9. Partap U, Partap T. Managed Crop Pollination: The Missing Dimension of Mountain Agricultural Productivity. Mountain Farming Systems' Discussion Paper Series No. MFS 97/1.Kathmandu, ICIMOD, 1997.
10. Partap U, Partap T. Pollination of apples in China. Bee keeping and Development. 2000; 54:6-7.
11. Sihag RC. Why should bee-keeping be utilized as an input in agriculture? Current Science. 2001; 81:1514-16.
12. Suman RS. Attitude of Farmers towards sustainability of vegetable cultivation. Journal of Agri Search. 2014; 1(1):1-3.
13. Verma LR, Partap U. Foraging behaviour of *Apis cerana* on cabbage and cauliflower and its impact on seed production. Journal of Apicultural Research. 1994; 33:231-6.
14. Pandey AK, Singh AK, Singh SK, Kumar A. Livelihood sustainability of small and marginal farmers of Bihar through multiple use of water for enhancing agricultural productivity. Enviornment & Ecology. 2012; 30(4A):1529-33.