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Economic Impact of Sunflower Production Technologies under All India Co-ordinated Research Project in Karnataka

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Abstract

The results revealed that sunflower hybrid varieties and associated technologies contributed significantly to the output of sunflower as indicated by Total Factor Productivity (TFP) in Karnataka State especially in irrigated area. The research investment made on sunflower in Karnataka state (under jurisdiction of UASB) varied between ₹ 20.51 lakhs and ₹ 76.26 lakhs during the period 2001-11. The research investment made on sunflower in UAS, Bangalore jurisdiction yielded an internal rate of return (IRR) of 7.87 per cent which can be considered as reasonable. This implies that during the reference period, an investment of one rupee on sunflower research yielded a return of ₹ 0.0787 every year. More than 80 per cent of area under sunflower in Karnataka State is under rainfed, therefore, the productivity levels are very low. Hence, the future research endeavours on sunflower need to focus on augmenting the dryland productivity.

Keywords : Sunflower production, total factor productivity, returns to research investment

The state funding for agricultural research is dwindling worldwide over the years due to various reasons which calls for prioritisation of research investments for augmenting farm productivity and incomes. The economic value of returns from public investment in research may not be directly apparent to the society and governments as the adoption and impact of farm technologies are spread over a long-time due to their public good nature. Agricultural research and development (R&D) has real cost to the society because of foregone alternatives to invest resources in the next best alternatives. Therefore, its contribution to agricultural development should be great enough to justify the resources devoted. Hence, economic studies are needed to quantify productivity of R & D (flow of benefits) in order to demonstrate their impact on economic welfare and compare them with cost of research and extension. Further, documentation of research impact is essential to bargain and justify research investment in order to meet the expectations of the public.

The role of the State in augmenting agricultural productivity is crucial as private investment in agricultural research is very low and restricted to commercially important crops. As a result, private research technologies do not reach poor farmers due to high cost. This further necessitates large scale investment by the state in agricultural research. One of the modes of achieving self-sufficiency in food production in India has been the initiatives in agricultural research in the form of All India Co-ordinated Research Projects (AICRP) for important crops. The AICRP on sunflower functioning since 1977 has made concerted efforts to address the regional problems by developing production technologies suitable for different states including Karnataka, which has large area under sunflower cultivation.

Sunflower is an important oilseed crop in Karnataka state. It occupied an area of 356 thousand hectares (indiastat.com) in 2014-15 which was 60.36 per cent of total area under sunflower in the country. The aggregate production of sunflower in the state is about 206 thousand tonnes, which forms 47.44 per cent of aggregate production of the country.

The AICRP centre at University of Agricultural Sciences, Bengaluru is one of the pioneering research centres on sunflower. It has to its credit developing country's first hybrid sunflower BSH-1 and has developed several varieties, hybrids, production technologies and relevant package of practices for the cultivation of sunflower in the state. As a result of these research efforts, large scale adoption of sunflower technologies has significantly enhanced the

production and yields of sunflower in the state. The available research studies on economic impact and returns to research investment have mainly focussed macro level perspectives. The present study has made an attempt to focus on micro level perspectives of sunflower technologies and their impact on production. The specific objectives of the study are:

1. To estimate productivity improvement of sunflower due to hybrid technology under AICRP,
2. To quantify Total Factor Productivity of hybrid technologies of sunflower and
3. To assess the returns to research investment on sunflower.

METHODOLOGY

The present study was carried out geographical region pertaining to the jurisdiction of University of Agricultural Sciences, Bengaluru. The study is mainly based on the secondary data.

Data Base

Secondary data on district-wise time series data on area, production and productivity of State as a whole were collected from Directorate of Economics and Statistics, Govt. of Karnataka, Bengaluru for the period 1980-2011. Further, farm-level data on yield, use of inputs and their prices for sunflower were taken from the Farm Management Section, Department of Agriculture, Govt. of Karnataka for estimating Total Factor Productivity (TFP).

For the analysis of returns to research investment on sunflower, the investment made on sunflower research by the All India Coordinated Research Project (AICRP) of sunflower in UAS, Bengaluru was considered and used in the study as public-sector investment.

Analytical Tools / Techniques

Growth rates for area, production and productivity of sunflower grown in Karnataka state were estimated for the period 1980-2011. The study period was divided into three sub-periods. The first period corresponded to pre-hybrid era (1980-90). The second period signifies emergence and dominance of sunflower hybrids (1991-20) and the third period (2001-11) marked large scale import of edible oils which had a marked negative impact on the prices of edible oil seeds in general and sunflower in particular in the country. The exponential growth model was used for estimating growth rates as shown below :

$$Y = a\ b^t e \quad \ldots\ldots (1)$$

where,

Y = Dependent variable for which the growth rate is estimated (area, production and productivity of sunflower)
a = Intercept
b = Regression coefficient
t = Time variable
e = Error term

The exponential growth rate was obtained from the logarithmic form of the equation as below

$$\ln y = \ln a + t \ln b$$

The per cent exponential growth rate (g) was derived using the relationship

$$g = (\text{Anti ln of } b - 1) \times 100$$

Total Factor Productivity

The use of modern inputs will induce an upward shift in the production function to the extent of the technological change embodied in them. The total factor productivity (TFP), which is the ratio of output per unit of total factor inputs, measures the shift in output due to non-material inputs. Thus, TFP measures the amount of increase in total output which is not accounted for by the increase in total inputs (Kumar and Mittal, 2006). Farm harvest prices were used to aggregate the outputs. Inputs included in the input index were human labour, bullock labour, seed, manure, fertilizers, pesticides, irrigation, and depreciation. Inputs were aggregated using the factor shares with appropriate weights. TFP, thus indicates the contribution of non-material factors such as technology, infrastructure etc.

Total output, total input, total factor productivity and input price indices are calculated as given below:

Total output index (TOI) –

$$TOI_t / TOI\ t\text{-}1 = \pi_j \left(\frac{Qj_t}{Qj_{t-1}} \right)^{(Rj_t + Rj_{t-1})^{1/2}}$$

Total input index (TII) –

$$TII_t / TII\ t\text{-}1 = \pi_j \left(\frac{Xi}{Xi_{t-1}} \right)^{(Si_t + Si_{t-1})^{1/2}}$$

Total factor productivity index (TFPI) –

$$TFPI_t = \pi_j \left(\frac{TOI_t}{TII_t} \right) \times 100$$

Input price index (IPI) –

$$IPI_t / IPI_{t-1} = \pi_i \left(\frac{Pi_t}{Pi_{t-1}} \right)^{(Si_t + Si_{t-1})^{1/2}}$$

Where,

R_{jt} - is the share of output 'j' in total revenue
Q_{jt} - is output 'j'
S_{it} - is the share of input 'i' in total input cost
X_{it} - is input 'i'
P_{it} - is price of input 'i', all in period't'

By specifying TOIt-1, TIIt-1 and IPIt-1 equal to 100 in the initial year, the above equations provide the total output, total input, total factor productivity and input price indices for the specified period 't'.

Total factor productivity is a ratio of total output index to the total input index or the value of total output to the total input cost multiplied by 100 that is, expressed in percentage over the years. The total factor productivity is an indicator of impact on output due to research / technological advances and extension over and above the input or factor contribution to the total output.

Returns to Research Investment

Returns to research investment is an important policy issue in agricultural economics. By focusing the breeder seed production and associated package of practices or technologies released by the AICRP center, Bengaluru, returns to research investment was estimated. From total breeder seed production from the AICRP centre, total commercial cultivated area of sunflower that can be planted was arrived at. The output that can be obtained from this area was estimated by multiplying commercial area and average yield per ha. By multiplying the price with production, the total value of product was estimated and this value was multiplied with actual TFP of respective years to get value of output contributed by technologies in sunflower (TFP). The value of sunflower output so derived was used for estimation of internal rate of return (IRR).

Returns to research investment in sunflower was assessed in terms of internal rate of return (IRR). Many agricultural economists have used IRR as an appropriate tool to estimate returns to research investment (Chand *et al*., 2011; Mruthyunjaya *et al.,* 2004). IRR reveals the incremental returns every time period for an incremental investment of one rupee in sunflower research. The IRR was estimated as below:

$$IRR = \sum_{t=1}^{n} \frac{B_t - C_t}{(1+d)^t} = 0$$

Where,

IRR – Internal rate of return
B_t – Benefit in rupees
C_t – Cost in rupees (research investment)
d – Discount rate

Results and Discussion

Growth rates in area, production and productivity of Sunflower

Investment on sunflower research and development resulted in release of the first variety, EC-6841 from Bengaluru centre in 1975 and country's first hybrid in sunflower was released in 1980. Subsequently a number of sunflower hybrids were released in the state by the AICRP centre. Due to release of high yielding varieties and hybrids, the area in Karnataka under sunflower increased from 37,787 ha in 1980-81 to 4,94,099 ha in 2000. However, it started declining in succeeding years including current decade due to various reasons. Growth rates of area, productivity and production were estimated using exponential growth function for four periods. During the first period (1980-1990), area registered an annual growth rate of 32.07 per cent per annum (Table I).Thus, the total output was mainly contributed by area growth rather than productivity growth.

During the second period (1991-2000), all economic variables registered negative growth rate with

TABLE I

Exponential growth rates of area, production and productivity of sunflower - all sub-periods (1980 - 2010)

Years	Particulars	Growth rate (%)
1980-1990	Area	32.07 **
	Production	28.58 **
	Productivity	-2.10
1991-2000	Area	-5.82 **
	Production	-7.90 **
	Productivity	-2.19
2001-2010	Area	5.91
	Production	3.52
	Productivity	-2.25
1980-2010	Area	6.15 **
	Production	5.61 **
	Productivity	-0.50

Note: ** indicates significance at 5 per cent

total production registering highest negative growth, while productivity decline was slower which may be due to import of edible oil on large scale. This might have had negative impact on sunflower oil prices and consequently on the area and productivity. In the third period, due to large scale import of palm oil, domestic produced edible oils suffered badly. In this period, the popular hybrid (KBSH-44) in terms of productivity was released which led to increase in area and total production.

Total Factor Productivity of Sunflower

The total factor productivity (TFP) is an economic measure used to assess the contribution of non-material inputs especially technology and infrastructure in the production of a commodity. To a large extent, the productivity (in terms of value of output) of resources is dependent on magnitude of technological innovations adopted by the farmers, market, better road facilities etc. In the present study, technologies released by AICRP on sunflower were considered for TFP in sunflower as described in the methodology section. The year 1990-91 was considered as the base year. In the year 1992, the first hybrid variety KBSH-1 was released for commercial cultivation. In 2001, 2002 and 2008 a number of hybrids were released by AICRP in Karnataka.

TFP for sunflower varied from 1.13 in 1991-92 to 1.06 in 2010-11 (Table II). TFP growth had fallen to 0.62 in the year 1994-95 and again in the year 2002-03 to 0.65. The TFP was very low (0.52) during the year 2008-09. The highest TFP was recorded during the year 1995-96 (2.08). This year corresponds to the release of 3 hybrid varieties of sunflower, hence, the TFP was highest. Average TFP for the 21 years was 1.15 revealing that the contribution of sunflower technology was 15 per cent. The output growth has fallen to 0.61 in 2000-01 as well as in 2006-07 and reached lowest in 2008-09 (0.50). The highest output growth (2.30) was observed in the year 2007-08. In the case of input growth, wide fluctuations were observed. It had decreased from 1.12 in 1991-92 to 0.94 in 2010-11. The highest (2.07) input growth was recorded in the year 1994-95.

TABLE II

Total factor productivity of sunflower in Karnataka from 1990-91 to 2010-11

Observation years	Total input growth	Total output growth	Total factor productivity
1990-91	1.00	1.00	1.00
1991-92	1.12	1.27	1.13
1992-93	0.96	1.32	1.37
1993-94	0.58	0.63	1.09
1994-95	2.07	1.29	0.62
1995-96	0.53	1.11	2.08
1996-97	1.24	1.21	0.98
1997-98	0.81	0.91	1.13
1998-99	1.16	0.88	0.76
1999-00	1.10	1.45	1.32
2000-01	0.84	0.61	0.73
2001-02	1.39	1.93	1.39
2002-03	1.09	0.71	0.65
2003-04	0.57	1.13	1.99
2004-05	0.93	0.85	0.92
2005-06	1.02	1.11	1.09
2006-07	0.91	0.61	0.67
2007-08	1.13	2.30	2.05
2008-09	0.96	0.50	0.52
2009-10	1.06	1.63	1.54
2010-11	0.94	0.99	1.06
Average	1.02	1.12	1.15

During the reference period, TFP growth was positive within a few years of inception of AICRP indicating the positive impact of technologies developed by the center on sunflower production in the state. However, during the years 1994-95, 1996-97, 1998-99, 2000-01, 2002-03, 2006-07 and 2008-09 contribution of these factors was negative (Table II). This may be due to the adverse weather factors as opined by Kumar and Rosegrant (1994) or non-availability of complementary factors in required amounts. A large proportion of area under sunflower in Karnataka state is under rainfed cultivation masking often positive impact of sunflower technologies. But, adequate and timely rainfall is necessary for full manifestation of sunflower technologies. The technology can work efficiently if complimentary factors are available at optimal level. The contribution of technologies (mainly varieties / hybrids and package of practices) was positive on the productivity of sunflower. As a result, the total production of sunflower in Karnataka increased steadily over the years. However, the area under sunflower is declining despite positive contribution of technologydue to large scale import of palm oil.

Returns to Research Investment on Sunflower Crop in Karnataka

Under the AICRP, substantial research investment has been made in the state for the development of the sunflower high yielding varieties (HYVs), hybrid varieties and supporting technologies in the related agricultural disciplines. Table III reveals the public research investment in nominal terms on sunflower under the AICRP in Karnataka. For the present study, the research expenditure from 2001-02 onwards was considered as data prior to this was not available. During this year, a research expenditure of ₹ 30.39 lakhs was made on sunflower research under UASB jurisdiction which worked out to ₹ 121.56 per ha. During the year 2010-11, the public research investment doubled to ₹ 73.91 lakhs and average investment per ha was ₹ 127.43 in nominal terms.

The return to research investment in sunflower was assessed in terms of internal rate of return (IRR). IRR reveals the incremental returns for each time period for an incremental investment of one rupee in sunflower research. The total value of sunflower output

TABLE III

Returns to research investment in sunflower in Karnataka

Year	Total area (lakh ha)	Total productions (tons)	Research expenditure (₹ in lakh)	Research expenditure (₹ /ha)	Incremental production (lakh tons)	Additional value (₹ in crores)	TFP
2001-02	0.25	14294	30.39	121.56	55.32	5.26	1.39
2002-03	0.80	50734	15.64	19.55	-175.74	-23.00	0.65
2003-04	0.56	50387	22.56	40.29	500.15	58.93	1.99
2004-05	0.61	55388	33.10	54.26	-47.02	-6.46	0.91
2005-06	1.08	89100	20.51	18.99	76.00	14.57	1.09
2006-07	0.71	55340	23.20	32.68	-181.63	-40.89	0.66
2007-08	0.77	48310	36.99	48.04	505.66	77.55	1.98
2008-09	0.84	53304	39.41	46.92	-256.87	-73.96	0.53
2009-10	0.38	26192	76.26	200.68	141.88	32.80	1.56
2010-11	0.58	45427	73.91	127.43	25.30	6.58	1.06
Internal Rate of Return (IRR)					**7.87 %**		

from AICRP center was evaluated taking into account the total area that could be planted with sunflower hybrid seeds. Using the TFP of sunflower, the contribution of AICRP, Bangalore center was evaluated as depicted in Table III and based on these figures, IRR was worked out.

The results presented in Table III showed that in 2001-02, the additional income due to TFP was 5.26 crores and the highest additional returns were obtained during 2003-04 which was 58.93 crores. The negative returns (-73.96 crores) was seen in the year 2008-09. The research expenditure (₹ 200.68 per ha) was highest in the year 2009-10 and the lowest in 2005-06 (₹ 18.99 per ha). In the study period of ten years, only in six years positive returns were observed and in the remaining four years negative returns were observed.

The estimated IRR for research investment on AICRP Begaluru center was 7.87 per cent (Table III). The IRR of 7.87 per cent is quite reasonable because the research and technological output is considered as the public good for which expected rate of return would be rather low. Instead of private rate of return, the social rate of return needs to be considered for research and development projects as benefits of such research is available to a large public body. Generally, the expected social rate of return for the public projects of this type is 2-4 per cent per annum. Therefore, it can be inferred that research investment on sunflower is positive both on social and commercial considerations.

Results of the study demonstrated that the impact of sunflower technologies (TFP) is conspicuous in augmenting the productivity and production of sunflower in Karnataka state. However, the impact of these technologies was not fully manifested due to climatic and economic factors. Added to these, prices of sunflower in real terms are on the decline, which in turn may act as disincentive to farmers. More than 80 per cent of area under sunflower in the state is rainfed, therefore, the productivity levels are very low. To improve the dry land productivity, research initiatives need to be focussed to evolve drought resistant sunflower varieties.

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