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STRATEGIES FOR INCREASING AREA AND PRODUCTIVITY OF SUNFLOWER (*Helianthus annuus* L.) IN INDIA

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ABSTRACT

Sunflower (*Helianthus annuus* L.) is an important oilseed crop of India. There has been consistent decline in its production for last one and a half decade. The production has declined from 1.46 million tonnes (m t) in 2007-08 to 0.23 m t in 2020-21. A mission mode approach is required to increase the area and productivity of sunflower in the country. Relative Spread Index (RSI) and Relative Yield Index (RYI) were estimated for 181 districts to identify the potential areas. Based on RSI and RYI values of 250 and 125, these districts were grouped into four categories *viz*., most efficient, efficient, moderately efficient and inefficient. The inefficient districts were ignored. Of these, 11 and 13 districts were selected for productivity enhancement and area expansion, respectively. For these selected 24 districts, district-wise technologies were mapped. Front line demonstrations (FLDs) were conducted in six districts. In all the districts, FLDs plots recorded higher seed yield and gross monetary returns compared to farmers' practice plots. Further, the strategies for productivity enhancement and area expansion were discussed.

Keywords: Frontline demonstrations, Potential districts, Relative Spread Index, Relative Yield Index, Strategies, Sunflower

Sunflower (*Helianthus annuus* L.) is an important oilseed crop of India. The oil content in the seeds varies from 35 to 43 per cent. The monounsaturated fatty acids such as oleic and linoleic comprise about 90 per cent of the total fatty acids in oil and may reduce heart diseases. Sunflower oil is rich in polyunsaturated fatty acids like omega-3s and omega-6s and it reduce cholesterol and triglycerides. Sunflower oil has good keeping quality. Sunflower hulls are used in animal feed as a source of roughage, as a fuel to generate steam or electricity and in production of furfural and ethyl alcohol. Crop diversification is shift from traditional and less remunerative to more remunerative crops. Sunflower can play an important role in crop diversification because of its short duration, photo-insensitive nature, and wide adaptability to different agro-climatic regions. Sunflower + soybean in Maharashtra, sunflower + urdbean in Uttar Pradesh are found to be efficient for increasing productivity and monetary returns and coarse rice-potato-sunflower recorded higher returns (Rs.70262/ha) compared to coarse rice-wheat system (Rs.35881/ha) in Punjab and Haryana (Reddy and Suresh, 2009). There was phenomenal growth in sunflower area and production since its, introduction in the country in 1970s up to 2002-03 (Fig.1). Area under sunflower increased from about 0.1 million ha in 1970s to 1.63 million ha in 2002-03 (Indiastatagri, 2020). Sunflower production has drastically declined from 1.463 million tonnes in 2007-08 to 0.23 million tonnes in 2020-21. Currently sunflower is grown in India on an area of 0.228 million ha with a production of 0.212 million tonnes and productivity of 0.93 t/ha (Indiastatagri, 2020). India shares 1.25 per cent of total area and contributes 0.58 per cent production of sunflower in the world (Food and Agricultural Organization, 2019). The important sunflower growing states are Karnataka, Andhra Pradesh, Maharashtra, Telangana, Bihar, Tamil Nadu, West Bengal, Punjab, Haryana and Uttar Pradesh.

The Compound Annual Growth Rates (CAGR) for area, production and yield were 1.16, -2.09 and -3.14, respectively during the period of 1971-80. Area and production showed positive growth rates of 25.7 and 21.16 during 1981-90 but yield showed negative growth rate of -3.57 during the same period. It was mainly due to the versatile nature of sunflower, which is photo insensitive, short duration, and ability to fit in various cropping systems. The area peaked till 1993-94 and showed declining trend after 1994 due to import liberalization and reduction in import tariff. The area (-2.97), production (-3.18) and yield (-0.02) showed negative trends during 1991-2000. The trend reversed during 2001-10 and showed positive growth rate of 4.31 in area, production (6.12) and yield (1.75) in comparison to the 2001 year due to the adoption of improved hybrids,

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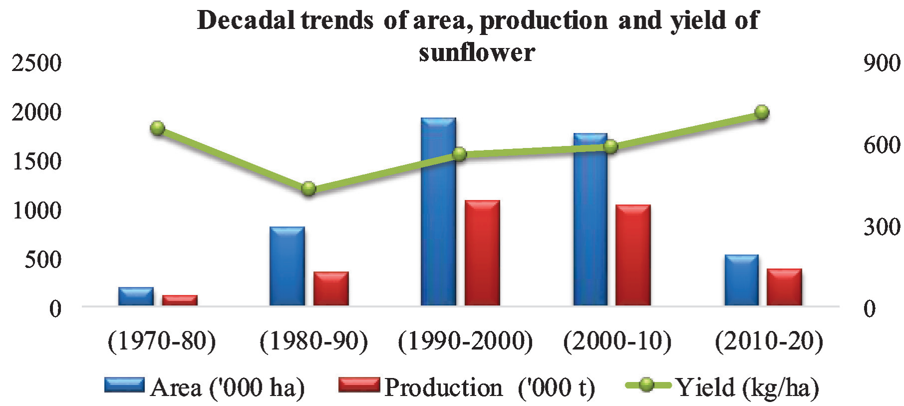

Fig. 1. Decadal trends of area, production and yield of sunflower

remunerative prices and low incidence of pests and diseases. The area and production drastically declined during 2011-20 with negative growth rates of -15.1 and -13.07, respectively mainly due to the incidence of necrosis diseases coupled with non-remunerative prices, but the yield showed positive growth mainly due to adoption of improved technologies by the farmers.

The major reasons for low productivity of sunflower are its production under sub-optimal agro-ecological conditions, rainfed cultivation, small operational land holdings, lack of varietal replacement, losses due to pests and diseases, low knowledge level and low adoption of improved cultivars, technologies and other management practices by farmers (ICAR-Indian Institute of Oilseeds Research, 2020). For increasing the crop productivity, it is important to identify the potential areas (districts) and follow a pragmatic approach for transfer of improved technologies. In potential areas based on sunflower area, districts were selected for area expansion and productivity enhancement and district wise strategies were formulated for improvement of productivity and increase of area in sunflower. Hence, the objective of the present study was to identify efficient districts and formulate strategies for increasing the production and productivity of sunflower in India.

MATERIALS AND METHODS

Relative Yield Index (RYI) and Relative Spread Index (RSI) values are often used for such studies. Different workers used different RSI and RYI values. Pavithra *et al.* (2020) had taken RSI and RYI values of 125-75 and 100-75, respectively; Sankar and Kowshika (2020), Sankar *et al.* (2019), Kokilavani and Geethalakshmi (2013) had taken RSI and RYI values of 100; Ramamurthy *et al.* (2018) used RSI and RYI values of 125 and Naidu *et al.* (2015) had taken RSI and RYI values of 90 for categorization of efficient cropping districts.

For identifying efficient districts, Relative Yield Index (RYI) and Relative Spread Index (RSI) were estimated based on the methodology of Kanwar (1972). The following formulae were used for estimation of RSI and RYI.

$$\text{RSI} = \frac{\text{Area of the particular crop expressed as \% of total cultivable area in the district}}{\text{Area of that crop expressed as \% to the total cultivable area in the country}} \times 100$$

$$\text{RYI} = \frac{\text{Mean yield of a particular crop in a district}}{\text{Mean yield of that particular crop in the country}} \times 100$$

These indices were calculated based on crop area and productivity mean of 5 years. The district-wise secondary data related to area and productivity and total cultivable area of sunflower in 10 major states (Karnataka, Andhra Pradesh, Maharashtra, Telangana, Bihar, Tamil Nadu, West Bengal, Punjab, Haryana and Uttar Pradesh) were collected for the period, 2014-15 to 2018-19 from the respective states (Directorate of Economics and Statistics, 2019).

RSI and RYI values were taken based on mean of all districts of 10 major sunflower growing states. The RSI and RYI values of 250 and 125, respectively were considered for identifying the efficient districts by narrowing down the districts to have more focus and mission mode approach.

Based on these indices, the districts were grouped into four categories. RSI and RYI values of >250 and >125 for most efficient cropping districts, <250 and >125 for efficient cropping districts, >250 and <125 for moderately efficient cropping districts and <250 and <125 for inefficient cropping districts. Based on the RSI and RYI values, 16 districts were identified as most efficient, 99 districts as efficient, 21 districts as moderately efficient and 45 districts as inefficient for sunflower production. From most efficient, efficient and moderately efficient districts, based on the area under sunflower crop during 2019-20, districts were categorised into two groups' *viz*., districts with sunflower area more than 1000 ha for area expansion and districts with sunflower area more than 5000 ha for productivity enhancement. Accordingly, 13 and 11 districts were identified for area expansion and productivity enhancement, respectively to have a much-focussed approach.

Table 1. Categorization of Efficient districts

Efficient	RSI	RYI	No of Districts
Most Efficient	>250	>125	16
Efficient	<250	>125	99
Moderately efficient	>250	<125	21
In-efficient	<250	<125	45

The improved technologies were selected for each location based on the recommendation of the nearest AICRP-sunflower centre. Improved technology (IT) was demonstrated in comparison with farmers' practice (FP) on 0.40 ha plot during *rabi* 2019-20 in order to provide farmers an opportunity to compare, evaluate and choose themselves the best practice based on their own criteria. FLDs were conducted on sunflower crop in six districts (Bagalkot, Haveri, Nizamabad, 24 Paraganas South, Raichur and Solapur). The data on seed yield, cost of cultivation and gross monetary returns were collected from the IT plots and FP plots by the respective AICRP centres. The following formulae were used for estimation of various parameters:

Increase in yield with IT over FP = (IT-FP) / FP *100

Benefit cost ratio (BCR) = Gross monetary returns (GMR) / Cost of Cultivation (CoC)

Partial budgeting technique (Birthal, 2003) was used to estimate additional net returns of the demonstrations. The technology is economically feasible, if the profits are higher compared to those of farmer's practice. This could be symbolically represented as:

$TR(I) - TR(F) > TC(I) - TC(F)$

$\Delta R(I) > \Delta C(F)$

$TR = \Sigma Pi.Yi$

$TC = \Sigma Pj.Xj$

Where TR (I) = Total returns from the improved technology plot

TC (I) = Total cost recorded in improved technology plot

TR (F) = Total returns from farmers' practice plot

TC (F) = Total cost recorded in farmers' practice plot

ΔR (I) = Change in the revenue due to improved technology

ΔC (F) = Change in the revenue due to farmers' practice

Pi = Price of the i^{th} output (i =1, 2... n)

Yi = Quantity of the i^{th} output (i = 1, 2... n)

Pj = Price of the j^{th} input (j = 1, 2... n)

Xj = Quantity of the j^{th} input (j = 1, 2…. n)

Table 2. Districts selected for area expansion and productivity enhancement

Area expansion (Area in ha during 2019-20) (Efficient Districts)	Productivity Enhancement (Area in ha during 2019-20) (Efficient Districts)
Ambala (2840) (ME)	24 Paraganas South (6490) (ME)
Fatehgarh Sahib (2000) (ME)	Kurukshetra (6220) (ME)
Kadapa (4980) (ME)	Bagalkot (39917) (Mod E)
Kannauj (2121) (ME)	Belgaum (12142) (Mod E)
Madhepura (1330) (ME)	Bellary (13688) (Mod E)
Nizamabad (3282) (ME)	Bijapur (8994) (Mod E)
Chikmagalur (1716) (Mod E)	Chamarajanagar (6028) (Mod E)
Chitradurga (1083) (Mod E)	Gadag (14690) (Mod E)
Haveri (3876) (Mod E)	Gulburga (7472) (Mod E)
Osmanabad (1210) (Mod E)	Koppal (27762) (Mod E)
Raichur (3990) (Mod E)	Solapur (13610) (Mod E)
Thoothukudi (1875) (Mod E)	
Virudhunagar (1825) (Mod E)	

ME = Most Efficient district and Mod E = Moderately efficient district

RESULTS AND DISCUSSION

Productivity enhancement

Eleven districts were identified for productivity enhancement, two districts (Kurukshetra and 24 Paraganas South) were found most efficient and rest of nine (Bagalkot, Belgaum, Bellary, Bijapur, Chamarajanagar, Gadag, Gulburga, Koppal, Solapur) districts were moderately efficient. District-wise technologies suggested for productivity enhancement are given in Table 3 based on the location-specific research by the AICRP-sunflower centres for the districts.

Area expansion

For area expansion, six districts (Ambala, Fatehgarh Sahib, Kadapa, Kannauj, Madhepura and Nizamabad) were under most efficient category and seven districts (Chikmagalur, Chitradurga, Haveri, Osmanabad, Raichur, Thoothukudi and Virudhunagar) were under moderately efficient category. The district-wise technologies for area expansion were given in Table 4 based on the recommendations of AICRP-sunflower centres for the districts.

Productivity potential and profitability of improved technologies (FLDs)

In order to show the productivity potential and profitability of improved technologies, FLDs were conducted in six districts. Raichur, Nizamabad and 24 Paraganas South districts were selected for productivity enhancement and Bagalkot, Haveri and Solapur districts for area expansion. The results of FLDs are given in Table 5. In all the districts, improvement in seed yield, gross monetary returns, additional net returns and B:C ratios were observed in IT plots as compared to FP plots.

Similar results were reported by Kalarani *et al*. (2009) who observed that in CO-4 cultivar, foliar application of boric acid (0.3%) and NAA (40 ppm) resulted in higher yield (1289 kg/ha) as compared to local control plots (1053 kg/ha). Dayanad *et al.* (2016) found that mustard crop demonstrated plots got higher returns (Rs.1625) compared to farmers practice yield (Rs.1407). Naik *et al.* (2016) reported 18.84 per cent increase in seed yield and B:C ratio of 3 with sunflower hybrid RSFH-130 in Kalaburagi (Karnataka) in comparison to local farmers practice/cultivar. Mamgai *et al.* (2017) obtained 9.82 and 15.53 per cent higher seed yield of sunflower in Punjab and Haryana, respectively over the local check. These studies clearly indicated the productivity potential and profitability of improved technologies under farmers' situations vis-à-vis farmers existing practices. There is a need to upscale the results of the demonstrations to the entire sunflower area of the districts. Necessary partnerships need to be forged with all the stakeholders involved in sunflower production, technology outreach, training and marketing. Further large scale FLDs employing cluster approach need to be conducted in other districts identified by the study. Farmers need to be trained in choosing the right cultivars for their situations, integrated nutrient management and application of boron and sulphur, IPM and sunflower based intercropping systems.

In conclusion, the study identified 11 districts for productivity enhancement and 13 districts for area expansion. Demonstration of improved technologies through FLDs particularly in clusters indicated the

Table 3. District-wise technologies for productivity enhancement.

Efficient districts	State/districts	Key Technologies
Most efficient	Haryana- Kurukshetra (spring)	DRSH-1, HSFH-848, Kaveri Champ. Management of *Spodoptera*, *Alternaria* leaf spot, white fly.
Moderately efficient	Karnataka (*rabi*)- Bagalkot, Bellary, Belgaum, Bijapur, Chamarajanagar, Gadag, Gulburga and Koppala	DRSH-1, KBSH-53, KBSH-78, RSFH-130, RFSH-1887, prefer legumes in sequence with sunflower for better productivity, soil test-based fertilizer management, foliar application of B @ 2 per cent per litre of water at ray floret stage, management of leaf hopper, white fly and *Spodoptera*, necrosis, leaf curl, *Alternaria* leaf spot and powdery mildew diseases.
	Maharastra-Solapur (*rabi*)	Phule Raviraj, LFSH-171, DRSH-1, dibbling of sunflower seed at 30 cm distance in the center of both sides of ridges open at 120 cm distance along with 100 per cent RDF (N-60, P_2O_5-90, K_2O-60 kg/ha) for *kharif* rainfed condition, seed priming (carbendazim 2 g/kg seeds + thiamethoxam @ 0.04 per cent) + spray of propiconazole @ 0.1 per cent azadirachtin @ 0.15 per cent as soon as disease appears and the 2nd spray 15 days later.
Most efficient	West Bengal- 24 Paraganas South (*rabi*)	DRSH-1, LSFH-171, S @ 40 kg/ha as *Ammonium sulphate*. Opening of furrows in between rows @ 30-35 DAS.

Table 4. District-wise technologies for area expansion.

Efficient districts	State/districts	Technologies
Most efficient	Andhra Pradesh-Kadapa (*rabi*)	NDSH-1012, NSFH-1001, NDSH-1, APSH-11, Application of *Azospirillum* or *Azotobacter* saves 20-30 kg N/ha. Apply pendimethalin @ 1 kg a.i./ha (PE)+ fenoxyprop ethyl (Whip Super) @ 37.5 g a.i./ha at 15-20 DAS as directed PoE. Management of *Alternaria* leaf spot, *Spodoptera, Helicoverpa armigera.*
	Bihar-Madhepura (spring)	KBSH-1, TNAU-SUF-7, Seed treatment with *Azospirillum* or *Azotobacter* could save 50 per cent of recommended nitrogen. Management of *Alternaria* leaf spot, necrosis disease, powdery mildew, *Sclerotium rolfsii*.
	Haryana- Ambala (*rabi*)	HSFH-848, Kaveri Champ, management of *Alternaria* leaf spot, downy mildew, charcoal rot, head rot.
Moderately efficient	Karnataka (*rabi*)-Chikmagalur, Chitradurga, Haveri	KBSH-78, RSFH-1, management of thrips, leaf hopper, semiloopers, head borer.
	Karnataka-Raichur (*kharif*)	RSFH-1, RSFH-188, RSFV-901(Kranthi), In groundnut + sunflower (3:1) intercropping system and application of 50 per cent N as basal or top-dress. management of leaf hopper, necrosis disease, leaf curl, white fly and powdery mildew.
	Maharastra-Osmanabad	SS-56, TAS-82, LSF-8, LS-11, LSH-3, LSFH-171, Phulebhaskar, PDKVSH-952, Sowing of the hybrid LSFH-171 on ridges and furrows at 60 cm x 30 cm spacing and application of 125 per cent RDF (100:75:37.5 NPK kg/ha) is recommended. Management of thrips, white fly, leaf hopper, head borer, spodoptera, *Helicoverpa armigera.* Use of sulphur @ 45 kg/ha once in the cropping system (rice + sunflower and sunflower + groundnut) benefits the seed and oil yield besides maintaining soil fertility especially sulphur. In pigeon pea + sunflower (1:1) intercropping system, 100 per cent N (50 per cent as basal and 50 per cent as top dress).
Most efficient	Punjab-Fatehgarh Sahib (spring)	PFH-569, PSH-1962, management of *Alternaria* leaf spot, charcoal rot, head rot.
Moderately efficient	Tamil Nadu (*rabi*)-Thoothukudi, Virudhunagar	Co-5, CoH-3, TCSH-1, In groundnut + sunflower (3:1), recommended NPK and 50 per cent N as basal or top-dress.
		Co-5, CoH-3, TCSH-1, Incorporation of black gram residue, adoption of site-specific target yield of NPK with 5 t FYM/ha and application of *Trichoderma viride* to sunflower + sulphur+ limiting micronutrient B.
Most efficient	Telangana-Nizamabad (*rabi*)	LSFH-171, Prabhat (NDSH-1012), Management of *Alternaria* leaf spot, *Spodoptera*, *Helicoverpa armigera*. Intercropping systems of sunflower + groundnut (1:5) and sunflower + pigeonpea (2:1). Use of sulphur @ 45 kg/ha once in the cropping system (rice + sunflower and sunflower + groundnut) benefits the seed and oil yield besides maintaining soil fertility especially sulphur.
	Uttar Pradesh-Kannauj (*rabi*)	DRSH-108, DRSF-113. Management of thrips, white fly, powdery mildew.
	All states	Application of 7-8 tonnes of FYM before 2-3 weeks of sowing, soak the seed for 10 hours for better germination, seed treatment with thiram or captan @ 2-3 g/kg or metalaxyl @ 6 g/kg or imidacloprid @ 5 g/kg, sowing- *kharif* (rainy season), during second fortnight of June to mid-July, in light soils and up to second fortnight of August, in heavy soils and during *rabi* (winter season), September to first fortnight of October, seed rate-5 kg/ha, spacing- 60x30 cm, maintain optimum plant population of 55555 plants/ha, application of pendimethalin @ 1.0 kg a.i./ha as pre-emergence followed by interculture at 21 DAS and hand weeding at 40 DAS, thinning@10-12 DAS retain one seedling/hill, soil test based fertilizer management-, Boron @ 2 g/l of water at 55 DAS, soil application of S : 25 kg/ha, irrigation water at an interval of 20-25 days in black soils and 8-10 days in red soils, harvesting of crop at physiological maturity when the back of the head turns to golden yellow and the bottom leaves start drying and withering. Dry the seed heads for 2-3 days and storage at moisture content to around 9-10 per cent.

Table 5. Productivity potential and profitability of improved technologies of sunflower in *rabi* 2019-20.

State	District	FLDs (No)	Seed yield (kg/ha)		Increase in seed yield (%)	CoC (Rs./ha)		GMR (Rs./ha)		ANR (Rs/ ha)	BCR	
			IT	FP		IT	FP	IT	FP		IT	FP
Karnataka	Raichur	16	1933	1726	12	26537	27728	79271	70779	9683	2.99	2.55
Telangana	Nizamabad	55	1900	1600	18.8	26250	25000	98800	83200	14350	3.76	3.33
West Bengal	24 Paraganas South	98	1439	1150	25.1	25838	22826	46489	30695	12783	1.80	1.34
Karnataka	Bagalkot	36	975	850	14.7	17900	16800	34125	29750	3275	1.91	1.77
Karnataka	Haveri	87	1464	1260	16.2	21000	19500	51240	44100	5640	2.44	2.26
Maharashtra	Solapur	10	854	613	39.3	15933	12431	33493	19745	10697	2.1	1.6

CoC = Cost of Cultivation (Rs. /ha), GMR=Gross Monetary Returns (Rs. /ha), ANR = Additional Net Returns (Rs. /ha), BCR = Benefit Cost Ratio, IT = Improved Technology, FP = Farmer's Practice

scope for increase in area, production and productivity. There is need to develop necessary partnership among the stakeholders and encourage adoption of improved technologies. The convergence of the efforts of all the stakeholders will help in increasing area and production of sunflower in the country.

Authors' contribution

Conceptualization of research work and designing of ethodology/experiments (GDSK); Execution of field/ lab experiments and data collection (BC); Analysis of data and interpretation (NM); Preparation of manuscript (RSS)

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