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Best management practices for doubling oilseed productivity: Aiming India for self reliance in edible oil

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ABSTRACT

India is one of the largest producer, consumer and importer of edible oilseeds in the world. The diverse agro-climatic conditions favour cultivation of all primary and secondary sources of oilseeds including tree borne oilseeds (TBO) in India. *Kharif* oilseed crops are important, which determine the total oilseed production in the country up to a large extent. Flawed agronomic practices, high incidence of biotic and abiotic stresses are the reasons for overall low oilseed productivity in the country. The impact of stresses can be minimized through improved agronomic practices. Further, best agronomic practices are complementary to harness genetic yield potential of high yielding varieties. In long run the soil test- crop response based soil fertility management and use of *Sesbania* green manuring, crop residue management led to higher seed yield. Crop establishment methods like furrow irrigated raised bed (FIRB), Zero tillage (ZT) with residue retention also affect growth and productivity. The micro-irrigation with proper irrigation scheduling, not only improve seed and oil yield but also saves substantial irrigation water. Sunflower, groundnut, sesame crops are potential options during summer fallow in irrigated areas, likewise short duration improved varieties of mustard create promising opportunities under rice fallow areas. Oil palm is also gaining popularity and has huge untapped potential in India. The genetic improvement, along with best package of practices and their adoption in larger areas by the farmers will certainly be a step forward to achieve self-reliance in oilseed crops.

Key words: Groundnut, Improved Management, Oilseed Crops, Rapeseed-Mustard, Seed Productivity, Soybean

India has achieved self-reliance in food grain production long back and during 2017-18 ever highest food grain production of 284. 0 MT which is phenomenal for science led agri-growth in the country. Similar efforts are required for sustainable high level of production in oilseed crops in India. The country is meeting its edible oil demand by importing 50% of total requirement. India has incurred ₹ 73.0 thousand crore ($10. 8 million) during 2016-17 on import of edible oils to meet edible oil requirement. India's vegetable oil economy is world's fourth largest after USA, China and Brazil. Oilseed accounts for 13% of the Gross Cropped Area, 3% of the Gross National Product and 10% value of all agricultural commodities. With low levels of input usage for oilseed crops, their productivity is also stagnating around 1.0 t/ha. Almost 72% of the total oilseeds area is confined to rainfed farming cultivated mostly by marginal and small farmers. (Anonymous 2018a). It is expected that during 2017-18, record production of oilseed crops (31.31 MT) will be achieved with production of 10.98, 9.18, 8.32 and 1.57 MT of soybean, groundnut, rapeseed-mustard and castorseed respectively (Anonymous 2018b). The per capita availability of edible oil has reached to 18.3 kg/year during 2014-15, which is 50.2 g/capita/day against the recommended 30g per day to meet average physiological needs.

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Oilseed crops in India

The diverse agro-climatic conditions in India favour cultivation of nine annual oilseed crops soybean,groundnut, rapeseed-mustard, sunflower, sesame, safflower and niger,castor and linseed. Oilseeds cultivation is undertaken across the country in about 26.2 Mha predominantly under marginal soils, of which 72% is confined to rainfed conditions. The production and productivity of oilseed crops in India are 32.1 MT and 1225.0 kg/ha (Anonymous 2018a). The primary sources of edible oil include Groundnut, rapeseed-mustard, soybean, sunflower, sesame, safflower and niger and non-edible group castor and linseed. Whereas, cotton seed, rice bran, maize germ, plantation crops, coconut, red-oil palm, tree borne oilseeds (TBO) include sal seed, mahua, phulwara, kokum, mango-kernel, simarouba) are important secondary oilseed sources. Among the nine cultivated oilseed crops in India, soybean shares maximum

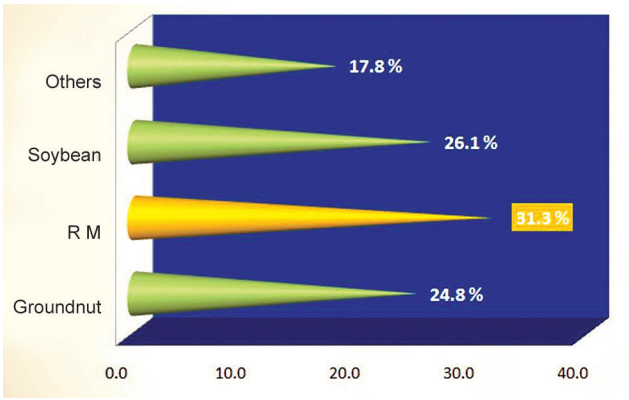

Fig 1 Contribution of different edible oilseed crops in domestic edible oil production.

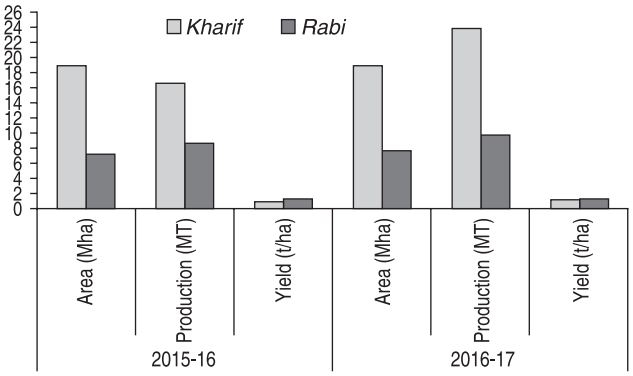

Fig 2 Area, production and productivity of *kharif* and *rabi* oilseed crops in India.

to total oilseeds production (39%) followed by groundnut (26%) and rapeseed-mustard (24%). Similarly, the highest acreage to total oilseed area is of soybean (36%) followed by rapeseed-mustard (23%) and groundnut (22%). But with regard to domestic source of edible oils, rapeseed-mustard is contributing the most (31.3%), followed by soybean (Fig 1).

Approaches to enhance productivity of kharif oilseed crops

India has higher acreage, production from *kharif* oilseed crops but the productivity of *rabi* oilseeds is slightly higher (Fig 2). Soybean, groundnut, sesame, castor seed, nigerseed and sunflower are key *kharif* oilseeds. On an average, total Kharif oilseed crops contribution to total production is about 67% and the remaining 33% is of *Rabi/summer* oilseed crops.

Table 1 Area, production and productivity of *kharif* oilseed crops during 2015-16

Crop	Area (Mha)	Production (MT)	Productivity (kg/ha)
Soybean	11.6	8.57	738
Groundnut	3.84	5.38	1399
Sesamum	1.92	0.85	436
Castor seed	1.06	1.75	1652
Nigerseed	0.25	0.07	295
Sunflower	0.16	0.07	420

Source: Directorate of Economics & Statistics, Department of Agriculture, Cooperation and Farmers Welfare

Kharif oilseeds have higher incidence of biotic and abiotic stresses, which cause decline in productivity. Soybean and groundnut crops are covering about 80% of total *kharif* area and producing about >70% of total *kharif* output (Table 1). Groundnut the 13th most important food crop and 3rd most important oilseed crop of the world (DOD 2017).

Soybean

Soybean is the most important oilseed crop India, being grown over an area of 11.7 Mha (Table 1), it contains >40% protein but lesser oil 20-25%. Madhya Pradesh, Maharashtra and Rajasthan contributes about 92-93% of area and production of soybean in India,however, cultivation of soybean is fast expanding in the states of Telangana, Karnataka and Gujarat (AICRP-S2018). Its meal cake is an important export item, widely used as protein supplement. The average yield of soybean was recorded as 1166 kg/ha with highest in Andhra Pradesh (1435 kg/ha) followed by Rajasthan (1302 kg/ha) and Maharashtra (1188 kg/ha). Soybean is mainly grown as rainfed crop on Vertisols soils in the areas of average crop season rainfall of 750- 900 mm. There exist huge yield gap due to poor adoptions of improved cultivation practices of soybean. The states of Chhattisgarh and Karnataka have yield gap over 100% (Table 2).

Improved agronomic practices for harnessing genetic yield potential: Soybean is mainly grown as rainfed crop (96. 4%) and due to uneven distribution ofrainfall and drought conditions at critical stages of crop growth the soybean,

Table 2 Soybean yield achieved in FLD field/farmer field and at state level

State	Average yield in FLD (kg/ha)		State average yield(kg/ha)	Yield gap over FP (%)	Yield gap over state average yield (%)
	IT	FP			
Chhattisgarh	2133	1620	949	32	125
Karnataka	1642	1356	626	28	162
Madhya Pradesh	1943	1379	1032	41	88
Maharashtra	1978	1552	1112	30	78
Rajasthan	1565	1236	961	23	63
All India	1786	1391	1068	28	67

(Status paper on Oilseed crops, 2014, Directorate of Oilseed Development, Hyderabad (GoI))

Table 3 Improved varieties of soybean for different conditions and stresses

Agro ecologies	Improved varieties
High yielding varieties for normal conditions	JS 20-34, DSB 23-2, JS 20-34, JS-20-29, JS 335, PK 416, PK 472, PK 327, RVS 2001-4, Jawahar Soybean 97-52 (JS 97-52)
Tolerant to stemfly, defoliators	JS 335, PK 262, NRC 12, MACS 124, NRC 7, NRC 37, JS 80-21, Pusa 16, Pusa 20, Pusa 24, PS 564, PK 472
Soybean rust	JS 80-21, PK 1029, PK 1024, Indira Soya 9
Yellow mosaic	PK 416, PK 472, PS 564, PK 1024, PK 1029, PS 1042, PS 1092, SL 295, Ankur, PK 327, PK 416, PS 564

yield is declining. Mostly soybean is cultivated as *kharif* crop. However, for seed production it is taken in *rabi* after paddy or maize as well. It is always better to practice varietal diversification of using 3-4 high yielding varieties in soybean growing areas to minimize incidence of diseases and insect pest (Table 3). This enables timely sowing and harvesting, minimize biotic and abiotic stresses. On the basis of 29 years data on FLD, AICRP-Soybean reported 384% yield increase due to improved agronomic practices. In moisture deficient soils, one pre-sowing irrigation prior to harrowing is must to obtain good germination. Timely sowing (20th to 25th June), optimum seed rate 75 kg/ha (small seeded varieties) and 100 kg/ha (bold seeded varieties), seed treatment with Carbendazim, Thiram, Thiamethoxam or Imidacloprid. Use of biofertilizer like Rhizobium (400 g per 65-75 kg seed) and PSB, alongwith recommended dose of fertilizers @ 20: 40: 40:30 kg N: P: K: S/ha are good in harnessing high productivity of soybean (DOD 2017).

Water management: Integrated conservation and production technologies of soybean with watershed as a unit of management to ensure maximum *in situ* rainwater conservation. As > 90% area under soybean is rainfed therefore *in situ* rainwater conservation promise of immense use. There exists enormous variation in soil fertility at macro and micro level, and blanket nutrient application in an area, not only resulted in poor crop response but also low NUE. It has been reported widely that site specific nutrient managementled to better soybean productivity under different locations. SSNM helps the farmers to amend fertilizer dosages to make up the nutrient gap SSNM aims to apply nutrients at optimal rates and times in order to achieve high productivity and nutrient use efficiency, leading to a higher profitability (Wit *et al.* 2007).

Weed management: Weed infestation cause 40-60% yield losses in soybean, the critical period of weed competition for soybean in 15-60 days after sowing(Jha and Soni 2013). Two hand weedings at 30 and 45 DAS recorded maximum weed control efficiency, and grain yield of soybean (Halvankar *et al.* 2005). Kosta *et al.* (2011) reported that two hand weedings (20 and 40 DAS) gave excellent weed control and higher (2735 kg/ha) grain yield of soybean than any herbicidal combinations. Prachand *et al.* (2015) observed in soybean, that post-emergence application of imazethapyr 10% SL @ 75-100 g /ha and quizalofop-pethyl 5 EC @ 50 g/ha in soybean enhanced the grain yield by 45.3% and 36.0%, respectively. Jha and Soni (2013) at Jabalpur reported maximum weed control efficiency (80.01%) with application of pendimethalin (0.75 kg/ha) followed by imazethapyr (0.75kg/ha). However transgenic soybean for glyphosate resistance is becoming increasingly popular in many countries. FAO, 2012 reported that the countries like Argentina, Brazil, Paraguay and Uruguay account for around 50% of world production and are, respectively, the world's second, third, fourth, and seventh largest exporters of this oilseed. The reasons are many for this success but it happened mainly due to large acreage (87.5%) under transgenic soybean (MGPA 2012).

Integrated pest and disease management in kharif oilseed crops: Soybean crop is affected by a number of pests which normally reduce the yield in the range of 15-30%. Stem fly, Blue beetle and white fly, are major insect pest of soybean. For prevention of stem fly treat the seed with Thiamethoxam 30 FS @ 10 g/kg seed before sowing, spray the crop with Quinalphos 25EC @ 1.5 l/ha at seedling stage when population exceeds 4 beetles/m for control of blue beetle and for white fly treat the seed with Thiamethoxam 30 FS @ 10 g per kg seed; install yellow sticky traps, remove YMV infected soybean plants and spray of pre-mix insecticide Betacyfluthrin + Imidacloprid @ 350 ml/ha for the control of white flies at later stage.

Groundnut

India shares about 25% of groundnut area and produces about 19% to global groundnut production. The average groundnut productivity in India is relatively low and even lower than the world average. Groundnut production in India is mainly confined in Gujarat, Andhra Pradesh, Tamil Nadu, Karnataka, Maharashtra and Rajasthan states. Groundnut is being grown during *kharif* (85%), *rabi* (10%), summer (4%) in India. There are more incidences of pest and diseases during *kharif* season, therefore selection of suitable tolerant high yielding varieties (Table 4) and proper seed treatment are essential to ensure good plant stand.

Seed treatment with *Trichoderma harzianum* or *T. viride* or *Pseudomonas fluorescens* @ 10 g/kg seed or Carbendazim or Mancozeb @ 3-4 g/kg seed or Tebuconazole @ 1.25g/kg is good for managing fungal attack in groundnut. In groundnut foliar application of Carbendazim (0.025%) + Mancozeb (0.2%) at 2-3 weeks interval, 2 or 3 alternate spray of Mancozeb (0.2%), Carbendazim (0. 02%) and Mancozeb (0.2%) @ 2 ml/L at 30, 50 and 70 DAS effectively reduces the early leaf spot and late leaf spot severity. Both short and long-term exposure to high air and soil temperatures can cause up to 50% yield loss in groundnut. The day temperature >34°C hamper seed-setting. The optimum temperature regimes for different critical stages ranged from 25-35°C. For germination, flowering and pod development

Table 4 Improved varieties of groundnut under different conditions

Agro ecologies	Improved varieties
High yielding varieties for normal conditions	Girnar-2, ICGS 76, ICGS 86, Kadiri-6,TPG-41, TG-37-A, GPBD-4, DH-86, TG-38, RG-382, ICGV-91114, Narayani, Kadiri-9),Raj Mungphalli-2 2015, GJG-18 (JSP-49), Anantha, TCGS-1043
Resistant to leaf minor	BR 2, ICGV 87160, ICGV 86031, ICGV 86699
Resistant to hoppers and thrips	Girnar 1, Co-1, Dh-3-30, ICGS 11, MH 1, POL 2, S 206
PBND tolerant	Ratneshwar (LGN 1), Vasundhara (Dh 101), Ajeya (R 2001-3), Pratap Raj Mungphalli, Mallika, GJG-31 (J-71)

the optimum temperature range is from 25-30, 25-33 and 30-35°C respectively. Generally fields are prepared by 2-3 ploughing through cultivator followed by planking and cultivation of groundnut in CA based management with reduced tillage has been reported. Groundnut sowing in broad bed and furrow (BBF) and ridge and furrow systems gives higher yield besides, conserving the soil and water (Fig 3).

The normal seed rate for bunch type and spreading-semi-spreading varieties is 100-110 kg/ha and 95-100 kg/ha, respectively. The optimum crop geometry is for bunch type varieties is 30 × 10 cm while for runner type varieties the it is 45 × 10 cm or 30 × 10 cm. Criss-cross sowing in groundnut gives 18% higher yield. The proper soil moisture should be maintained at critical stages of peanut like flowering (20-40 DAS), pod formation, development (40-70 DAS) and pod filling (70-100 DAS). Water requirement of groundnut ranges between 450 and 650 mm. The drip irrigation increases crop yield by 25-40%, saves up to 40-50% irrigation water and hence becoming popular in groundnut growing areas.

Herbicides recommended for use in groundnut: Weeds are causing huge losses in groundnut yield during *kharif* season; therefore an integrated weed management involving all possible measures will be the most effective and economical. The herbicides are becoming integral part of integrated weed management. Use pendimethalin as pre-emergence @ 1. 0 kg ai/ha, and post emergence spray any one of Quizalofop ethyl, Oxyfluorfen and Imazethapyr at the rate of 0. 05, 0. 2-0. 40, 0. 04-0. 05 kg ai/ha will control all types of weeds in groundnut crop.

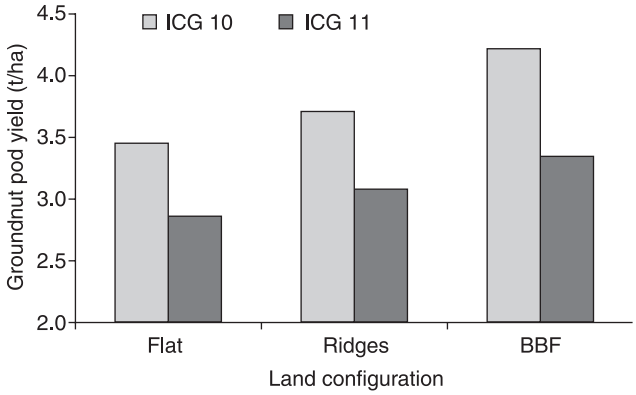

Fig 3 Groundnut pod yield, as influenced by different land surface configuration on an Alfisol (Wani *et al.* 2005).

Approaches to double the productivity of rabi oilseed crops: Rapeseed-mustard (R-M) is widely grown globally, with largest area of 8.3 Mha in Canada, followed by China (7.3 Mha), European Union (6. 75Mha) and India (5.76 Mha) with global area at 35.5 Mha (2015-16). The world average R-M productivity is of 2144 kg/ha, highest (3640 kg/ha) in European Union, whereas the Indian average productivity is only 1151 kg/ha (Bharat *et al.* 2018). Rapeseed-mustard, groundnut, sunflower, linseed and safflower are noteworthy *rabi* oilseed crops and among all Indian mustard (*Brassica juncea*) is of predominant significance (Table 5).

Improved varieties of rapeseed-mustard: Since, there is a vast variability in the climatic and edaphic conditions in the R-M growing areas of India, the selection of appropriate cultivars is important as it helps in getting higher response of the crop to applied inputs and management. Since inception of mustard research programme in India, number of HYV's, tolerant to various abiotic and biotic stresses have been developed (Table 6).

Improved cultivation practices: The improved agronomic practices are equal and complementary to harness genetic yield potential of high yielding improved oilseed varieties. *Orobanche,* a root parasite is becoming menace in many areas, and single approach is not effective to control this weed. Rathore *et al.* (2014) has reported integrated management practices for effective control of *Orobanche*. The rapeseed-mustard is an oilseed crop, therefore application of Sulphur (40.0 kg/ha) along with NPK of 80-40-40 kg/ha resulted in higher seed and oil yield. It is always better to use fertilizers on the basis of soil test basis. Integrated nutrient management including *Sesbania* as green manure and 2.5 t/ha of mustard crop residue resulted in maximum seed yield of mustard at Bharatpur (Premi *et al.* 2012).

Conservation agriculture based management: Higher mustard seed yield was observed under furrow irrigated

Table 5 Area, production and productivity of *rabi* oilseed crops during 2015-16

Crop	Area, Mha	Production, MT	Productivity, kg/ha
Mustard	5.75	6.80	1183
Groundnut	0.76	1.37	1801
Sunflower	0.32	0.23	698
Linseed	0.26	0.13	477
safflower	0.13	0.05	416

Source: Directorate of Economics & Statistics, Department of Agriculture, Cooperation and Farmers Welfare

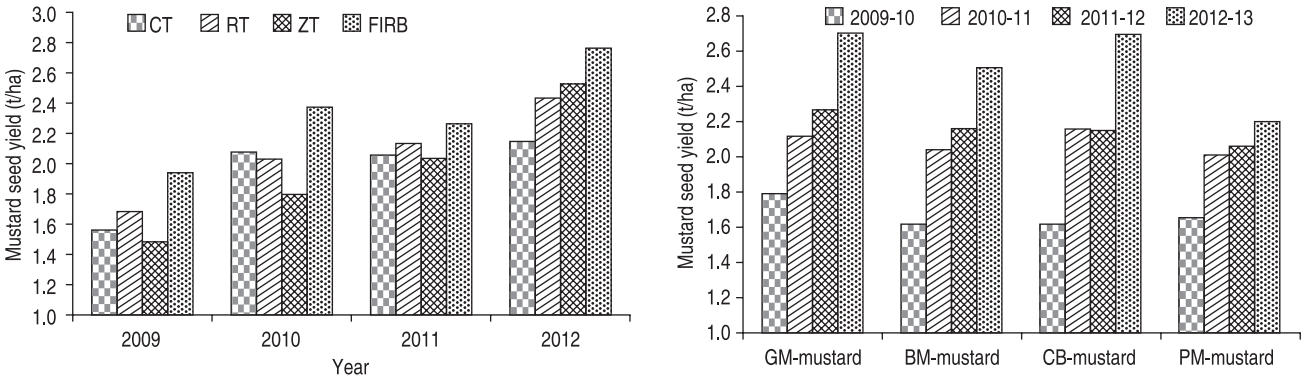

Fig 4 Seed yield of mustard under different tillage systems and interaction effect of tillage methods and cropping systems.

Table 6 Varieties tolerant to various abiotic and biotic stresses of mustard (*Brassica juncea*)

Specific abiotic/ biotic stress	Tolerant verities
Irrigated	Pusa Bold, Pusa Vijay, Pusa Jai Kisan, RH 749, NRCDR 02, NRCHB 506
Rainfed	Aravali, Geeta, GM 1, PBR 97, Pusa Bahar, Pusa Bold, RH 781, RH 819, RGN 48, Shivani, TM 2, TM 4, Vaibhav, RB 50
Salinity tolerant	CS 52, CS 54, CS 56, Narendra Rai (NDR8501), NRCDR02
Frost tolerant	RGN 13, RH 819, Swaranjyoti, RH 781, RGN 48
High temperature tolerant	Kanti, Pusa Agrani, RGN 13, Urvashi, NRCDR 02, Pusa Mustard 25 (NPJ 112), Pusa mustard 27 (EJ 17)
White rust resistant	Basanti, JM 1, JM 2, NRCDR-2
Alternaria blight tolerant	Jawahar Mustard 3, Him Sarson 1 (ONK 1), Ashirwad (RK-01-03)

raised bed (FIRB), zero tillage (ZT) and reduced tillage (RT) in successive years (Fig 4). The strong positive correlation between SOC and CSPR with mustard productivity is likely due to improved soil physicochemical and biological properties. Green manuring before mustard enhanced the yield by 18. 4% over the fallow-mustard system. The green manure decomposes fast and supplies upto 38 kg N/ha, adds dry matter, improves SOC, and recycles nutrients to the soil. An increase in crop yield with increase in SOC concentration has been well documented for mustard (Shekhawat *et al.* 2018).

Irrigation management is of immense significance in enhancing seed productivity and irrigation water use efficiency in mustard crop. The micro-irrigation significantly improved seed and oil yield of Indian mustard compared to the crop irrigated by check basin irrigation. Hence Rathore *et al.* 2014 reported that overall, there was 28.6% increase in seed productivity of mustard crop under drip and micro sprinkler irrigation respectively (Fig 5). Micro irrigation resulted in IWUE between 35-38 kg/ha-mm and while under check basin it was only 14.5 kg/ha-mm over the years (Rathore *et al.* 2017).

Exploration for productivity enhancement in summer oilseed crops

Strategies for productivity enhancement in tree based oilseed: Sunflower, groundnut, sesame crops are cultivated even during summer season in irrigated areas. The crop has great potential for diversification of major cropping systems. It is relatively less thermo and photo insensitivity renders sunflower an ideal crop for all seasons and it can be gown during summer season in the areas of adequate irrigation facilities. The short duration high yielding hybrids can be a good option to utilize the land which mainly remained fallow during summer season. BSH-1, KBSH-1, PSFH-67, Jwalamukhi, Sungene-85, PAC-36,PSFH-118, KBSH-44, DRSH-1, PSFH-118, PSFH 569 are promising high yielding hybrids of sunflower, while Morden, DRSF-108, DRSF-113 are important sunflower varieties. Though Karnataka, Andhra Pradesh and Maharashtra are the major sunflower growing states contributing about 91% and 82% of the country's area and production respectively, the irrigated northwestern part of the country are also the potential areas of introduction of sunflower during summer season. Sunflower is mainly grown during *rabi* season but have potential to be cultivated in nay crop season throughout the year. In non-traditional Northern states like Punjab, Haryana, Uttar Pradesh, Bihar, the important sunflower based cropping system are maize-potato-sunflower, cotton-sunflower, fodder-potato-sunflower, fodder-potato-sunflower, fodder-mustard-sunflower, urdbean-mustard-sunflower, groundnut-mustard-sunflower. The sowing time is crucial for good

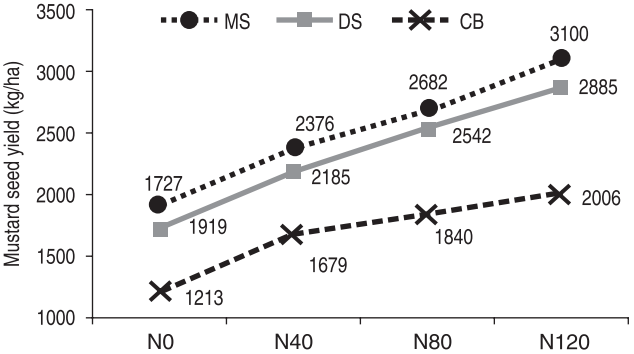

Fig 5 Higher mustard seed productivity under micro-irrigation.

sunflower crop and Directorate of Oilseed has suggested that in states like Punjab, Haryana,Uttar Pradesh, Bihar, West Bengal, Odisha and Chattisgarh, the optimum sowing time is January to February end. The suggested seed rates for rainfed is 6-7 kg/ha and for irrigated situation it is 5-6 kg/ha. For quick germination and better stand establishment in dryland conditions, soak the seed in fresh water (1:1 W/V) for about 10 hours and shade dry. Sunflower crop requires 9-10 irrigations during summer at an interval of 10-12 days in February 8-10 days in March, 6-8 days in April and 4-6 days in May depending upon soil type. Fertilizer application based on soil test are best strategy but general recommendation Uttar Pradesh, Punjab, Bihar and Haryana are 80, 60, 40, 20 kg /ha of N,P, k and S. Amongst micronutrients, boron is the most vital and spray of borax (0.2% i.e. 2 g/l of water) to capitulum at ray floret opening stage increases seed filling, yield and oil content. Kapila and Shivay 2008 reported increased yield attributes and seed yield with application of Boron.

Oil palm as potential oilseed in India: India imports edible oil of almost worth ₹ 70.0 thousand crore every year and a substantial portion of our requirement is met through import of palm oil from Indonesia and Malaysia. Oil palm is considered to be highest oil yielding source per ha. Average oil yield of oil palm is 4-5 tonnes per ha in Malaysia (Anonymous 2014). Two species of oil palm are cultivated in India, i.e. guineensis and olifera. It is a perennial potential crop for the states of Andhra Pradesh, Karnataka, Tamil Nadu, Mizoram, Kerala, Odisha, Gujarat, Goa, Maharashtra and Chhattisgarh. It gives quality production in humid climate especially under coastal tropical zones. In India, area under oil palm is 2.52 lakh ha (2013-14). Andhra Pradesh, Kerala and Tamil Nadu are the leading oil palm producing states, covering an area of area of 1.45, 0.40 and 0.29 lakh ha with production of fresh bunches of 11.4, 0.14 and 0.08 lakh tonnes respectively. There exists excellent scope for further area expansion in the North-eastern states and in the coastal regions of West Bengal, Telangana etc. (Anonymous 2016). The productivity of oil palm at yield stabilizing period (4-8 years) is 12 t/ ha and during yield stabilized period (>8 years) is 20 t/ha. However because of some limitations like long gestation period, small holdings size, fluctuation in prices, shortage of water, competition with other economically viable crops such as rubber, arecanut, sugarcane, banana, coconut etc, still oil palm cultivation is not getting due success.

India is one of the largest producers of oilseed crops and diverse agro-climatic conditions favour growing of different oilseed crops in India. But due to poor adoption of the best management practices, the productivity of most of the oilseed crops is far below their potential levels. Yield gaps in FLDs also highlighted across all the states in India. Also increasing consumption of edible oils (>50.0 g/ capita/day) more than the recommendation of WHO/ICMR (>30.0 g/capita/day) are the reasons for their deficit. There is urgent need to address various biotic and abiotic stresses in *kharif* and *rabi* oilseed crops and also to bring more areas under its cultivation through effective implementation of oilseed based crop diversification plans and through area expansion under fallow system. Oil palm is a big hope in India, it has been well documented that many states in India are exceedingly suitable for oil palm cultivation. There is need of proper technical, policy supports to the growers in terms of timely supply of inputs and ensure attractive market within and outside of India. It is beyond any doubt that with effective implementation of programme of genetic improvement supported with best agronomic practices to the farmers, India will achieve self-reliance in edible oilseed.

REFERENCES

Anonymous 2014. Status paper on oilseeds. Oilseed Division, Department of Agricultural and Cooperation, Ministry of Agriculture, Government of India.

Anonymous 2016. Agricultural Statistics at a Glance. Department of Agricultural and Cooperation, Ministry of Agriculture, Government of India.

Anonymous 2018a. Economic Survey 2017-18, Government of India Ministry of Finance, Department of Economic Affairs Economic Division January, 2018.

Anonymous 2018b. 4th Advance Estimates of production of major crops for 2017-18. Press Information Bureau. Government of India Ministry of Agriculture & Farmers Welfare.

Sharma B R, Gulati A, Mohan G, Manchanda S and Ray I. 2018. Water productivity mapping of major Indian crops. NABARD and ICRIER. pp 180.

DOD 2017. Status paper on oilseed crops. Directorate of Oilseeds Development, Government of India, Ministry of Agriculture & Farmers Welfare, (Department of Agriculture, Cooperation & Farmers Welfare), Telhan Bhavan, Himayatnagar, Hyderabad.

Halvankar G B, Varghese P, Taware S P and Raut V M. 2005. Effect of herbicides on weed dynamics and yield of soybean. *Journal of Maharashtra Agricultural University* **30**: 35–7.

Jha A K and Soni M. 2013. Weed management by sowing methods and herbicides in soybean. *Indian Journal of Weed Science* **45**: 250–2.

Shekhawat K and Shivay Y S. 2008. Effect of nitrogen sources, sulphur and boron levels on productivity, nutrient uptake and quality of sunflower (*Helianthus annuus*). *Indian Journal of Agronomy* **53**: 129–34

Kosta K, Upadhyay B, Rawat A and Uikey K. 2011. Efficacy of imazethapyr alone and in combination with other herbicides against weeds in soybean. *JNKVV Research Journal* **45**: 105–8.

MAGP 2012. Ministry of Agriculture, Livestock and Fisheries, AR; IICA (Inter-American Institute for Cooperation on Agriculture, CR). Comparative study of genetically modified and conventional soybean cultivation in Argentina, Brazil, Paraguay, and Uruguay. Technical Coordinators: P. Rocha, V. M. Villalobos. San Jose, CR, IICA.

Prachand S, Kalhapure A and Kubde K J. 2015. Weed management in soybean with pre- and post-emergence herbicides. *Indian Journal of Weed Science* **47**: 60–2.

Premi O P, Rathore S S, Shekhawat Kapila, Kandpa l B K and Chauhan J S. 2012. Sustainability of fallow-Indian mustard (*Brassica juncea*) system as influenced by green manure, mustard straw cycling and fertilizer application. *Indian Journal of Agronomy* **57**(3): 229–34.

Rathore S S, Shekhawat Kapila, Kandpal B K and Prem O P. 2017. Improvement of physiological and productivity traits of Indian mustard (*Brassica juncea*) through micro-irrigation and fertigation under hot semi-arid eco-region. *Indian Journal of Agricultural Sciences* **87**(9): 1257–62.

Rathore S S, Shekhawat Kapila, Premi O P, Kandpal B K and Chauhan J S. 2014. Productivity, water use efficiency and sustainability of pressurized irrigation systems for mustard under semi-arid conditions of Rajasthan. *Indian Journal of Agronomy* **59**(1): 112–8.

Rathore, Shekhawat, Premi, Kandpal and Chauhan. 2014. Biology and management of the fast-emerging threat of broomrape in rapeseed–mustard. *Weed Biology and Management* **14**: 145–58

Shekhawat Kapila, Rathore S S, Kandpal B K, Premi O P and Singh Dhiraj. 2018. Enhancing Carbon Sequestration Potential, Productivity and Sustainability of Mustard under Conservation Agriculture in Semi-arid Regions of India. *Proceedings of National Academy of Sciences, India, Section Biological Sciences* **88**(1):199–208.

Wani S P, Pathak P, Sachan R C and Pande Suresh. 2005. Conservation Tillage for Enhancing Productivity and Protecting Environment: ICRISAT Experience. Abrol I P, Gupta R K. and Malik R K (Ed). Conservation Agriculture Status and Prospects. Centre for Advancement of Sustainable Agriculture, New Delhi, pp 242.

Witt C, Pasuquin J M C A, Buresh R J and Dobermann A. 2007. The principles of site-specific nutrient management for maize. *Research Findings: e-ifc* No. 14, December 2007.