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Productivity enhancement of sesame (*Sesamum indicum* L.) through improved production technologies

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Sesame (*Sesamum indicum* L.) is most important oil seed crop in Madhya Pradesh. One of the major constraints of its low productivity is non-adoption of improved technologies. Front line demonstration were conducted at 65 farmers field, to demonstrate production potential and economic benefit of improved technologies comprising short duration, phillody (mycoplasma) resistant varieties, line sowing, integrated nutrient management and timely weed removal (TKG-55,TKG-306 and JTS-8), line sowing (45 × 10 cm), integrated nutrient management (60:30:15:40, NPKS kg/ha). The seeds were treated with phosphate-solubilzing bacteria each at 20 g/kg of seeds. Pre-emergence application of weedicide Pendimethalin at 1 kg a.i /ha used for effective control of the weeds during *Kharif* season of 2007 to 2008 to 2011 to 2012 in rainfed condition. The improved technology recorded a mean yield of 5.34 q/ha which was 34% higher than that obtained with farmers practice yield of 3.45 q/ha. The improved technologies resulted higher mean net income of Rs.12913.80/ha with a benefit cost ratio of 2.49 as compared to local practice (7740/ha, 2.20).

Key words: Sesame, frontline demonstration, improved technologies, net return, productivity.

INTRODUCTION

Sesame or gingelly (*Sesamum indicum*) commonly known as til (Hindi) is an ancient oilseed crop grown in India, and perhaps the oldest oilseed crop in the world. The crop is now grown in a wide range of environments, extending from semi-arid tropics and subtropics to temperate regions. Consequently, the crop has a large diversity in cultivars and cultural systems. India is the largest producer of sesame in the world. It also ranks first in the world in terms of sesame-growing area (24%). Figure 1 shows that the increase in sesame productivity is about 2% for Ethiopia and India and 2.8% for China in the period of 1990 to 2007 (FAO, 2008). Perhaps the productivity increase should better be interpreted as a linear trend with and increase of 7 kg/ha per year in India, 13 kg/ha per year in Ethiopia and 22 kg/ha per year in China. Clearly, the level and rate of increase of yield per hectare of sesame in China is more than 50% higher than in Ethiopia. This probably indicates a great opportunity for a prolonged and higher increase in sesame productivity in India. In order to realise this opportunity, an analysis is needed of the major current constraints limiting sesame productivity in India. Due to the increased production per hectare and the increase in acreage, India has become the first producing and exporting country (Figure 2).

The yield increase is due both to development and use of improved varieties and improved agronomy practices and crop protection. The potential yield of sesame still is much higher than actual yield, as still much damage occurs by pests and diseases, insufficient weed control, to high levels of monocropping, lack of mechanisation

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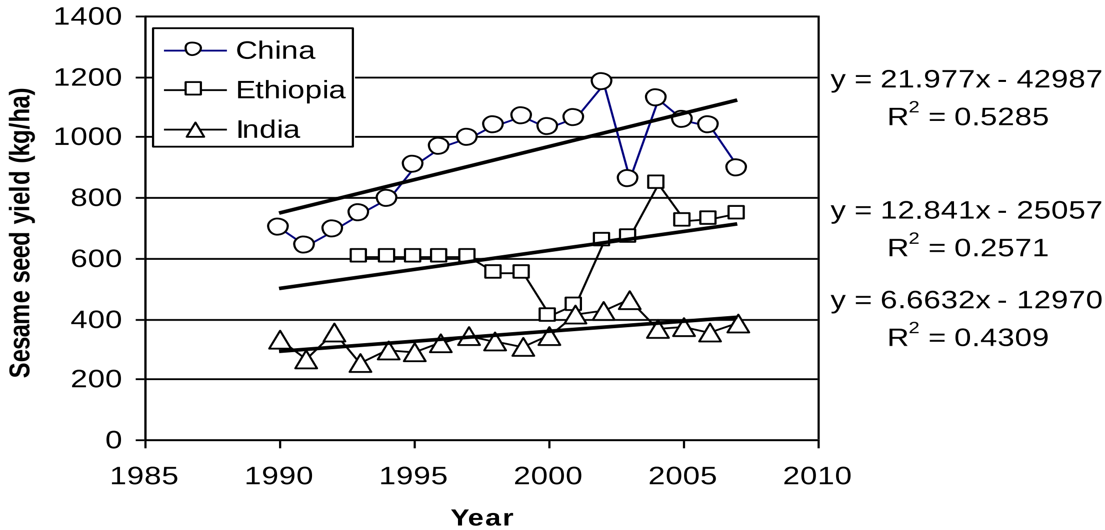

Figure 1. Sesame productivity in India, China and Ethiopia from 1990 to 2007 (FAO, 2008).

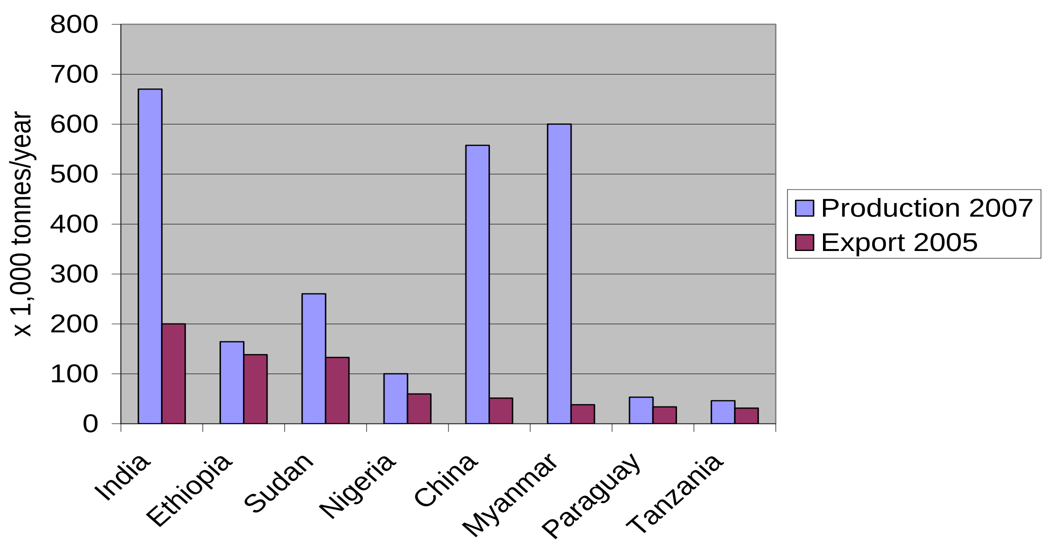

Figure 2. Comparison of total production and export of sesame seed of India compared with the major producing and exporting countries (data of 2007, FAOSTAT, 2008).

(amongst others causing seed shattering when not enough labour is available during harvest) and unrealised genetic potential. Potential yields are probably as high as 2000 kg/ha (Mkamilo and Bedigian, 2007).

Its seeds may be eaten fried, mixed with sugar or in the form of sweat meats. Sesame oil is used as a cooking oil in southern India. It is also used for anointing the body, for manufacturing perfumed oils and for medicinal purposes. Sesame cake is a rich source of protein, carbohydrates and minerals, such as calcium and phosphorus. The cake is edible and is eaten widely by working classes. It is also a valuable and nutritious feed for milch cattle. The oil is highly resistant to oxidative rancidity and exerts synergistic affect on the action of certain insecticides like pyrethrins and rotenone. Ryu et al. (1972) reported that sesame oil contains sesamolin and sesamine which is used as synergist for insecticides.

Sesame is grown in an area of 7.54 million hectares with a production of 3.34 million tonnes in the world with a productivity of 443 kg/ha (FAI, 2011). China, Myanmar and Sudan account for 40% of the world's sesame production. In India, sesame is grown in about 1.8 million hectares with a total production of 0.76 million tonnes and productivity of 422 kg/ha (FAI, 2011). West Bengal alone accounts for 25% of the total sesame production in India. The other major sesame-producing states are Gujrat, Madhya Pradesh, Tamil Nadu, Maharashtra, Karnataka, Rajasthan and Uttar Pradesh. The effect of plant population on yield and yield components have been reported by several workers. For example, seed yield per unit area increases with increases population density from 80,000 to 160,000 plant/ha and beyond this density in becomes counterproductive (Delgado and Yermanos, 1975). Also increased number of seed per capsule, number of capsule per plant, and dry mater production increased when the intra-row spacing increased from 30 to 90 cm (Weiss, 1983; Olowe and Busari, 1994).

In general, average productivity of sesame continues to be lower (144 to 234 kg/ha) than expected from agricultural technology for the last 20 years, mainly due to its cultivation on marginal lands, under poor management and without inputs except seed. The major constraint responsible for lower yield are inappropriate production technologies viz; broadcast method of sowing, no use of fertilizer and untimely weed management (45 DAS), (Khaleque and Begum, 1991). The yield of sesame can be increased by 21 to 53% with adoption of improved technologies such as improved variety, recommended dose of fertilizer, weed management and plant protection. Keeping this in view, frontline demonstrations on sesame were conducted to demonstrate the production potential and economic benefits of latest improved technologies on farmer's fields.

MATERIALS AND METHODS

Front line demonstrations were conducted on 65 farmers fields of five adopted villages viz; Sukwa, Barath, Doriya, Pannapura and Chokhada of Chhatarpur, District in Bundelkhand region of Madhya Pradesh during Kharif seasons of 2007 to 2008 to 2011 to 2012 in rainfed condition, on light to medium soil with low to medium fertility status under sesame-gram production system. Each demonstration was conducted on an area of 0.4 ha and the same area adjacent to the demonstration plot was kept as farmers practices. For many of the diseases and pests resistance occurs in sesame, e.g. resistance to phyllody (Singh et al., 2007), resistance to powdery mildew in India and phyllody (Gopal et al., 2005). The package of improved technologies included phillody (mycoplasma) resistant varieties, line sowing, integrated nutrient management and timely weed removal. The varieties of sesame TKG-55 in 2007 to 2008, TKG-306 2008 to 2009 and JTS-8 in 2009 to 2010 to 2011 to 2012 were included in demonstrations. The spacing was 45 cm between rows and 10 cm between plants in the row. Thinning should be done scrupulously to ensure recommended plant spacing within a row. The first thinning is done invariably 14 days after sowing and the second thinning 21 days after sowing. Excess population adversely affects growth and yield of crop. Seed was treated with Thiram at 2.5 g/kg seed for prevention of seed-borne diseases. Seed sowing was done between July-8-July 28 in 2007 to 2008, July 8-July 30 in 2008 to 2009, July 8-August 3 in 2009 to 2010, July 5-July 30 in 2010 to 2011 and July 5-July 28 in 2011 to 2012 with a seed rate of 5 kg/ha. Entire dose of N and P through diammonium phosphate and K through muriate of potash and sulphur at 60:30:15:40, respectively, was applied as basal before sowing. In India, highest net returns were found with 60 kg N/ha, 30 kg P/ha and 15 kg K/ha (Tripathi and Rajput, 2007). 40 kg S/ha productivity increased from 700 to 800 kg/ha with also a 3% higher oil content (increase from approx. 47 to 50%) (Maragatham et al., 2006). Hand weeding was done once at 25 days after sowing. Weeds were also controlled effectively by using of proper herbicides. In 2007 to 2008 the weedicide was used Diuron at 400-600 g/ha in 2008 to 2009 Basalin was used at 1 kg a.i/ ha, in 2009 to 2010 to 2011 to 2012 Pendimethalin was used at 1 kg a.i/ha as pre-emergence treatment for effective control of weed. The crop was harvested during September 30 to October 15 after the leaves turn yellow and start dropping while the capsules are still greenish-yellow.

RESULTS AND DISCUSSON

A total rainfall of 348, 623, 799, 653 and 556 mm was recorded in 32, 40, 47,45 and 42 rainy days during the crop season of 2007 to 2008, 2008 to 2009, 2009 to 2010, 2010 to 2011 and 2011 to 2012, respectively however, heavy rainfall (779 mm) was received in the first week of July (2009 to 2010). This caused an unusual delay in sowing during 2009 to 2010 and lowered productivity of sesame. The late planted crop finds relatively less time for plant growth and development. The sesame crop received 213.8 mm rains in 2008 to 2009 at maturity stage during first week of October. This caused seed sprouting and shattering in the capsule itself in standing crop conditions which lowered the productivity.

The yield attributing characters of number of capsule per plant under improved technology were 135.60, 115.20, 76.40, 95.00 and 95.60 as against local check (farmers practice), 100.2, 85.6, 45.8, 75.6 and 80.6 (Table 1) during the year 2007 to 2008, 2008 to 2009, 2009 to 2010, 2010 to 2011 and 20011 to 2012, respectively. There were 26.10, 25.69, 40.05, 20.37 and 15.69% increase in number of capsules under demonstration of improved technology over and above local check (farmers practice). The average number of capsules per plants were 103.56 under improved technology and 77.57 under local check, thus there were 25.58% more capsules per plant under improved technology demonstration as compared to local check. The average number of seeds per plant observed in improved technology was 71.06 as compared to 66.32 in local check. In the year 2007 to 2008, 2008 to 2009, 2009 to 2010, 2010 to 2011 and 2011 to 2012 the number of seeds per plants under improved technology and local check were 76.60 and 70.10, 72.50 and 69.50, 65.20 and 60.60, 70.2 and 63.20 and 70.80 and 68.20, respectively. The percentage increase in seeds per plants during these years were 8.48, 4.13, 7.05, 9.97 and 3.67 respectively with and overall average 6.66 seeds per plants. As regards test weight (g/100 seed) the observation showed that during the years 2007 to 2008, 2008 to 2009, 2009 to 2010, 2010 to 2011 and 2011 to 2012 the test weight under improved technology and local check were 3.00

Table 1. Yield attributing characters of Sesame.

Year	Rainfall during crop season (mm)	Rainy days during crop season (no.)	Yield attributing characters								
			No. of capsules/plant			No. of seeds/Capsule			Test weight(gm)		
			Improved technology	Local check	% increased	Improved technology	Local check	% increased	Improved technology	Local check	% increased
2007-2008	348	32	135.60	100.20	26.10	76.60	70.10	8.48	3.00	1.80	40.00
2008-2009	623	40	115.20	85.60	25.69	72.50	69.50	4.13	2.12	1.38	34.91
2009-2010	779	47	76.40	45.80	40.05	65.20	60.60	7.05	2.00	1.20	40.00
2010-2011	653	45	95.00	75.65	20.37	70.20	63.20	9.97	2.25	1.45	35.56
2011-2012	556	42	95.60	80.60	15.69	70.80	68.20	3.67	2.50	1.50	40.00
Average	591.8	41.2	103.60	77.60	25.60	71.10	66.30	6.70	2.40	1.50	38.10

Table 2. Seed yield of Sesame as affected by improved and local practices in farmers fields.

Year	Area (ha)	Demonstration (No.)	Yield (q/ha)			Local check	Additional yield (q/ha) over local check	% increased in yield over local check
			Improved technology					
			Maximum	Minimum	Average			
2007-2008	5.0	13	6.84	5.23	6.13	4.40	1.73	28.00
2008-2009	5.0	13	6.56	4.91	5.20	3.58	1.62	21.00
2009-2010	5.0	13	5.60	3.85	4.72	2.10	2.62	56.00
2010-2011	5.0	13	5.75	4.25	5.26	3.53	1.73	33.00
2011-2012	5.0	13	6.50	4.80	5.40	3.65	1.75	32.00
Average	5.0	13	6.25	4.61	5.34	3.45	1.89	34.00

and 1.80, 2.12 and 1.38, 2.00 and 1.20, 2.25 and 1.45 and 2.50 and 1.50 respectively with an average test weight 2.37 under improved technology and 1.47 under local check. The per cent increase in test weight during above year was found to be 40.00, 34.91, 40.00, 35.56 and 40.00 with an average of 38.09.

The productivity of sesame in Chhatarpur District of Madhya Pradesh in India under improved production technology ranged between 385 and 684 kg/ha with mean yield of 625 kg/ha. The productivity under improved technology varied from 523 to 684, 491 to 656, 385 to 560, 425 to 575 and 480 to 650 kg/ha with a mean yield of 613, 520, 472, 526 and 540 kg/ha during 2007 to 2008, 2008 to 2009, 2009 to 2010, 2010 to 2011 and 2011 to 2012, respectively (Table 2) as against a yield range between 210 and 440 kg/ha with a mean of 345 kg/ha under farmer's practices (local check). The additional yield under improved technologies over farmers practice ranged from 162 to 262 kg/ha with a mean of 189 kg/ha. In comparison to farmer's practice, there was an increase of 28, 21, 56, 33 and 32% in productivity of sesame under improved technologies in 2007 to 2008, 2008 to 2009, 2009 to 2010, 2010 to 2011 and 2011 to 2012. Respectively the increased grain yield with improved technologies was mainly because of line sowing, use of nutrient management and timely

Table 3. Cost of cultivation (Rs/ha), net return (Rs/ha) and benefit: cost-ratio of Sesame as affected by improved and local practices.

Year	Total cast of cultivation		Net return (Rs/ha)		B:C ratio		Additional cost of cultivation (Rs/ha)	Additional net return (Rs/ha)
	Improved technology	Local check	Improved technology	Local check	Improved technology	Local check		
2007-2008	6920	6348	11470	6852	2.66	2.08	572	4618
2008-2009	7040	5460	8560	4980	2.21	1.91	1580	3580
2009-2010	8075	5560	8919	5384	2.10	1.97	2515	3535
2010-2011	9620	8225	14366	7872	2.00	1.96	1395	6494
2011-2012	8500	6500	21254	13612	3.50	3.09	2000	7642
Average	8031.00	6418.60	12913.80	7740.00	2.49	2.20	1612.40	4457.80

Sale rate of Sesame 2007-2008 Rs. 3000/q, 2008-2009 Rs.3000/q, 2009-2010 Rs.3600/q, 2010-2011 Rs.4560/q 2011-2012 Rs.5510/q.

weed management.

Fertiliser response has been widely studied in other countries and the extent of the response depends on many factors: with high yielding varieties higher fertiliser rates are needed and also in cases of lower soil fertility. (Tripathi and Rajput, 2007). Sometimes micronutrients and improvement of cation exchange capacity proved helpful, for example by use of humix (humic acid preparation) (Abo-El-Wafa and Abd-El-Lattief, 2006) Hegde DM.1998 reported that integrated nutrient management increased productivity by 36% as compared to local variety of sesame. Kinman and Stark (1954) reported that adoption of improved variety increased productivity by 32% as compared to local variety of sesame. Improved technology produced higher grain yield in 2007 to 2008 to 2011 to 2012 as compared to local check. The reason for this could be the inter plant competition for the moisture and nutrients which could be more severe under local check demonstration (Farmers practice). Also, the higher weed infestation under the local check as evident from the higher weed cover and reduced the amount of nutrients and water available to the local check. This agrees with the findings of Weiss (1971), Imoloame et al. (2007) and Stonebridge (1963) who reported the superiority of row planting over broad casting to control weed and that this factor resulted in considerable yield increased and also grain yield increased significantly.

Phytopthora and Phyllody resistant variety, integrated The economic viability of improved technologies over traditional farmer's practices was calculated depending on prevailing prices of inputs and output costs (Table 3). It was found that cost of production of sesame under improved technologies varied from Rs 6920 to 9620/ha with an average of Rs.8031/ha as against Rs. 5460 to 8225/ha with an average of Rs.6418.60/ha under farmers practice (local check). The improved production technologies registered an additional cost of production ranging from Rs.572 to 2515/ha with an average of Rs. 1612/ha over local check. The additional cost increased in the improved technologies was mainly due to more cost involved in balanced fertilizer, improved seed and weed management practices. Cultivation of sesame under improved technologies gave higher net return which ranged from Rs 8560 to 21254/ha, with a mean of Rs.12913.80/ha as compared to farmers practices which recorded Rs. 4980 to 13612/ha with mean of Rs. 7740/ha. Similar results also have been reported by Khan et al. (2009). There was an additional net return of 4618 in 2007to 2008, 3580 in 2008 to 2009, 3535 in 2009 to 2010, 6494 in 2010 to 2011 and 7642 in 2011 to 2012 under demonstration plots. The improved technologies also gave higher benefit cost ratio, 2.26 2.21, 2.10, 2.00 and 3.50 compared to 2.08, 1.91,1.97, 1.96 and 3.09 under local check in the corresponding season the results from the current study clearly brought out the potential of improved production technologies in rainfed condition of Madhya Pradesh in India. To get maximum yield of sesame recommended package of practices should be followed. By not following any one management practice yield may be reduced severely and it was also observed that delay in sowing, unbalanced does of fertilizer, untimely weed management and plant protection drastically reduced the grain yield of sesame.

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