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Break even Soybean Yield Analysis under Frontline Demonstrations

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ABSTRACT

Frontline demonstrations were conducted at farmer's field across the country during 2013 to 2017 with the objective to demonstrate the impact of research emanated improved soybean production technology on soybean production under real farm situations. The results of 4518 frontline demonstrations revealed that the adoption of improved soybean technology enhanced the soybean yield to the tune of 28 percent as compared to farmer's practice. Break even yield analysis indicated the soybean yield would be higher than 741 and 647 kg/ha for profitable soybean production under current location specific market price of soybean.

Key words: Break even yield, break even cost, yield gap.

INTRODUCTION

Soybean, introduced for commercial cultivation in India during early 1970s, has established itself as a leading oilseed crop in the country and presently occupies first position among the nine oilseed crops in India. A spectacular growth in area and production of soybean has been achieved, but even after four and half decades of its commercial cultivation, productivity of soybean in India stagnated at around 1 to 1.1 t/ha whereas the global average productivity is well above 2.8 t/ha. The major reasons for low yield includes; slow pace of technology transfer and adoption, lack of awareness about production technologies in new areas, non-availability of quality seed and that too of improved varieties, imbalanced fertilizer use, timely unavailability of agrochemicals and other inputs, *etc.* In order to facilitate effective technology transfer and to achieve the targets, Government of India through Indian Council of Agricultural Research (ICAR) launched a programme during 1989-90, called Frontline Demonstrations (FLDs) on oilseeds and pulses. FLDs are conducted at farmers' fields under the direct supervision of scientists, with the major objective of demonstrating the production potential of improved production technology developed by research system for different agro-climatic regions on location specific basis, under real farm situations. The ultimate aim of the programme was to increase the rate of adoption of production technologies and improve productivity, and thus, farmers' income. Breakeven analysis for agricultural decision-making has been proposed and discussed by many scholars (Kay, 1986; Schmisseur and Landis, 1985; Forster and Erven, 1981; Herbst, 1976; Barnard and Nix, 1979; Giles and Stansfield, 1980). Enterprise budgeting enables farm managers to conduct breakeven analysis, estimate production costs, and select between competing crop production alternatives. The more common breakeven yield and price relationships have been expanded to include acreage or usage levels for machinery management by some of the researchers (Herbst, 1976; Forster and Erven, 1981; Barnard and Nix, 1979), and breakeven output price and yield analysis between agricultural enterprises (Casey, 1977; Herbst, 1976). While these serve as worthwhile decision-making tools, development of advanced breakeven analytical procedures has been suggested (Giles and Stansfield, 1980; Forster and Erven, 1981). Breakeven output price can be used as a simple risk management tool to evaluate the impacts of marketing decisions under price volatility. Maximum potential yield losses due to detrimental weather can be investigated with breakeven yield analysis. Breakeven analysis is also useful from the input side. Keeping these in view, the breakeven analyses were carried out to profitability of soybean cultivation in different states of India.

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METHODOLOGY

The frontline demonstrations were conducted during 2013 to 2017 at different centres spread over 15 states of the country and data pooled over the centers. The total of 4735 frontline demonstrations (Table 1) were carried out in different states at farmer's field on 0.4 ha each with research emanated improved soybean production technology (IT) and that were compared with farmer's practice (FP) for the period 2013 to 2017. The seed of newly released varieties and critical inputs were supplied to the farmers under improved production technology. The cost of cultivation under both the treatments was determined by using the prevailing market price of inputs and outputs.

Breakeven (BE) analysis was used to determine the values at which price, production, output and so on are adequate enough to cover specific costs (Chambers *et al.,* 1979; Baute *et al.,* 2002; Cook *et al.,* 2012 and Bhati *et al,* 2018). Based on current production and marketing systems, breakeven analysis was conducted for soybean production in different states of India. The minimum yield and price required matching the performance of the improved production technology and farmers practice was determined in order to cover the costs. The basic formula for breakeven analysis was adapted and solved for the variables of interest.

Break even yield (kg/ha) = Total Cost of Cultivation / Output price (₹/kg)

$$Y = \frac{VC + FC + \pi}{P_i}$$

$$IBCR = \frac{\text{Incremental gross returns from the demonstrated technology}}{\text{Incremental cost involved in demonstrated technology}}$$

Incremental net returns = Net returns from IT – Net returns from FP

The percentage yield increment in improved practice over farmers' practice was calculated across the states and for the country as a whole as weighted average using number of demonstrations as weights.

Breakeven revenue and price are the minimum revenue and price of soybean that is required to match the profitability of soybean. Total revenue is the product of yield and price. Also, cost of all material, machines and labour inputs were also considered for analysis. Gross returns have been worked out at prevailing market price in the respective area. The data of improved technology where comparable farmers practice was not available have been excluded from the analysis. BE yield is the minimum yield of soybean required to match the profitability of commercial soybean. BE yield can be compared between improved technology and farmers practice and also be used as an indicator for the competitiveness of improved production technology. In order to attempt to sell at a profit rather than taking a hit, it is important for soybean producers to know their breakeven yields.

RESULTS AND DISCUSSION

A total of 4735 frontline demonstrations were conducted across the country during the period under study, of which 4518 FLDs were taken for analysis and remaining data have not been included due to non-availability of comparable farmers practice data.

The highest number (>2000) of frontline demonstrations was conducted in the state of Madhya Pradesh which is known as soy state in the country followed by Maharashtra, Rajasthan, Karnataka, Uttarakhand, Himachal Pradesh and Jharkhand (Table 1), whereas in other states frontline demonstrations conducted were below hundred during the five year period. Among the states, the highest soybean yield was recorded in the state of Maharashtra and closely followed Telengana and Karnataka, while the lowest yield was found in the states of Tamil Nadu, Jharkhand and Himachal Pradesh under improved soybean production technology (IT). The yield varied between 1500 to 2000 kg/ha in the remaining states. Under farmers practice the similar trend was noted in terms of higher yield realized, while soybean yield was below than 1000 kg/ha in the state of Jharkhand and Chattisgarh.

The average over the states indicated that soybean yield was 1650 and 1289 kg/ha under improved production technology and farmers practice, respectively leading to the yield gap of about 28 per cent (Table 2 and 3).

Similar results were also reported by Billore *et al.,* (2005 and 2009) and Joshi *et al.,* (2004). Year wise analysis indicated that the soybean yield even with improved technology was lower during the years 2014 and 2015 mainly due to abiotic stress induced by long dry spells during critical crop growth stages coupled biotic stress in major soybean growing states (Table 2). It is noteworthy that even during adverse weather conditions adoption of improved crop production technology resulted in higher yield realization, and thus, farmers can minimize crop losses by adopting the technology.

Table 1: Soybean frontline demonstrations conducted in different states of India

State	2013	2014	2015	2016	2017	Total
AP/ Telangana	10	10	10	10	10	50
Bihar	-	-	-	20	5	25
Chhatisgarh	10	10	10	10	-	40
Gujarat	15	15	15	27	23	95
Himachal Pd	22	17	21	27	34	121
Jharkhand	20	20	20	20	20	100
Karnataka	95	95	95	120	18	423
Madhya Pd	326	360	500	422	479	2087
Maharashtra	50	60	225	192	216	743
Manipur	10	10	8	15	13	56
Meghalaya	-	-	10	10	10	30
Rajasthan	47	85	120	130	130	512
Tamil Nadu	10	10	10	10	10	50
Uttarakhand	11	12	14	15	134	186
All India	626	704	1058	1028	1102	4518

Table 2: Soybean yield (kg/ha) under frontline demonstrations and farmers practice in different states of India

State	2013		2014		2015		2016		2017		Overall	
	IT	FP	IT	FP	IT	FP	IT	FP	IT	FP	IT	FP
AP/ Telangana	1949	1479	1686	1324	1775	1503	2592	2193	2269	1970	2054	1694
Bihar							1577	1320	1694	1354	1600	1327
Chhatisgarh	1057	399	2499	906	1280	980	1901	1175			1684	865
Gujarat	1545	1371	1731	1448	1719	1420	1938	1687	1596	1257	1726	1453
Himachal Pd	1593	1177	1228	931	1172	893	1295	1016	1404	1107	1349	1038
Jharkhand	1417	1003	1468	1042	956	664	1317	972	1551	1128	1342	962
Karnataka	1976	1642	1696	1398	2016	1726	2060	1749	2076	1677	1950	1638
Madhya Pd	1520	1157	1711	1275	1063	773	1708	1358	1474	1183	1471	1132
Maharashtra	2134	1735	1832	1589	1932	1498	2421	2186	1975	1645	2076	1742
Manipur	1518	901	1518	931	1728	1013	1722	1088	1978	1177	1709	1037
Meghalaya					1800	1160	1367	973	1399	962	1522	1032
Rajasthan	1396	1027	1640	1211	1380	779	1516	1084	2008	1536	1619	1143
Tamil Nadu	1238	1084	1276	1045	1347	1087	1338	1068	1412	1128	1322	1082
Uttarakhand	1830	1526	1879	1538	1387	1138	1625	1357	1684	1210	1678	1256
All India	1629	1262	1697	1291	1406	1045	1846	1511	1685	1330	1650	1289

A comparison of adoption of improved crop production technology in terms of yield advantage over farmers' practice clearly brings out the potential of technology in improving the yield levels. The absolute quantity and percentage increase in yield over farmers' practice are presented on Table 3. With the adoption of improved soybean cultivation practices, on an average farmers can improve the soybean yield to the tune of 19 to 95 per cent across states as revealed by the yield increase in FLDs with full package of practices over farmers' practices (Table 3).

The maximum yield increment was found in Chhattisgarh state followed by Manipur, Meghalaya, Rajasthan and Jharkhand, indicating thereby that the poor know-how among farmers on improved soybean production technologies leading the low adoption and low yield. The yield increase from improved production practices in other states was below 30 per cent on an average for last five years. The similar pattern was also recorded in case of yield gap II which varied from 240 to 819 kg/ha. The national yield gap worked out to be in the range of 22 to 35 per cent from 2013 to 2017 indicating the possible increase in soybean productivity and production in the country by adoption of available improved production technology.

On an average, an increase of 28 per cent can be achieved which amounts to about 1650 kg/hectare which is 65 per cent higher than the national average productivity of around 1000 kg/ha, and during normal year the productivity with improved technology was 1846 kg/ha (during kharif 2016). Even if we consider the suggested 80 per cent possibility (Cassman, 1999) of bringing Frontline Demonstration performance as ground reality, the productivity of above 1500 kg/ha can be achieved. This leads to belief that from the present area of around 11.25 million hectares in the country (last five year average), an additional production of 5.85 million tonnes of soybean can be harvested with adoption of available improved technology against 10.98 million tones achieved on an average during last five years.

Table 3:Yield increase (%) and yield gap II (kg/ha) of soybean production in different states of India

State	2013		2014		2015		2016		2017		Overall	
	Increase	YG-II	Increase	YG-II	Increase	YG-II	Increase	YG-II	Increase	YG-II	Increase	YG-II
AP/ Telangana	31.8	470	27.3	362	18.1	272	18.2	399	15.2	299	21.3	360
Bihar							19.5	257	25.1	340	20.6	274
Chhatisgarh	164.9	658	175.8	1593	30.6	300	61.8	726			94.7	819
Gujarat	12.7	174	19.5	283	21.1	299	14.9	251	27.0	340	18.8	273
Himachal Pd	35.3	416	31.9	297	31.2	279	27.5	279	26.8	297	30.0	311
Jharkhand	41.3	414	40.9	426	44.0	292	35.5	345	37.5	423	39.5	380
Karnataka	20.4	334	21.3	297	16.8	290	17.8	312	23.8	399	19.1	312
Madhya Pd	31.3	363	34.2	436	37.6	290	25.8	350	24.6	291	30.0	339
Maharashtra	23.0	399	15.3	243	28.9	433	10.8	235	20.1	330	19.2	334
Manipur	68.5	617	63.1	587	70.6	715	58.3	634	68.1	801	64.9	673
Meghalaya					55.2	640	40.5	394	45.4	437	47.5	490
Rajasthan	36.0	369	35.4	429	77.2	601	39.9	432	30.7	472	41.6	475
Tamil Nadu	14.2	154	22.1	231	23.9	260	25.3	270	25.2	284	22.2	240
Uttarakhand	19.9	304	22.2	341	21.9	249	19.7	268	39.2	474	33.6	422
All India	29.1	367	31.4	406	34.6	362	22.2	335	26.7	355	28.1	362

Adoption of improved soybean production technology not only improves the yield realization, but also helps in improving monetary returns to the farmers. Additional monetary returns and incremental benefit cost ratio from adoption of improved technology over farmers' practice are presented on Table 4. The results revealed that farmers can earn additional net returns to the tune of ₹ 4000 to ₹ 35000 per hectare across different states, and ₹ 8000 to ₹ 10000 per hectare on an average of the states across years. The maximum incremental net returns were recorded in Manipur, Uttarakhand and Meghalaya states through adoption of improved production technology. The improved production technology was found economically viable (Mathur and Gupta, 1985; Thakur *et al.,* 1998; Joshi *et al.,* 2004). The returns to investment determine the profitability and thus, the extent of adoption of technology. The incremental benefit cost ratio was in the range of 1.5 to 17.5 per cent across years and states, indicating adoption of improved soybean production practices generates sufficient returns over investment and is profitable. The average IBCR of states also ranges from 3.1 to 4.8 per cent. The variation in incremental net returns IBCR across states and years was mainly on account of differences in practices adopted by farmers.

Table 4: Incremental net returns (₹/ha) and ICBR (%) from adoption of improved technology over farmers practice in different states of India

State	Incremental Net Returns (₹/ha)					Incremental Benefit Cost Ratio (ICBR in %)				
	2013	2014	2015	2016	2017	2013	2014	2015	2016	2017
AP/ Telangana	9595	8254	4759	4103	5364	2.8	3.0	2.0	1.6	2.4
Bihar				8156	11872				4.9	7.9
Chhatisgarh	18379	47923	2802	14121		5.0	6.5	1.4	2.8	
Gujarat	5272	8170	10401	6667	6680	16.4	14.2	16.6	6.4	3.3
Himachal Pd	7968	7049	10004	9951	10478	2.8	3.1	3.5	3.5	3.4
Jharkhand	6095	6235	3596	4830	8797	2.3	2.3	1.7	2.0	3.1
Karnataka	6830	4820	5913	5612	6736	2.9	2.0	2.7	2.4	2.3
Madhya Pd	8651	9156	6291	7241	5517	2.9	3.0	2.6	3.2	2.7
Maharashtra	8770	6243	14128	10580	12287	3.3	5.1	17.5	8.8	8.8
Manipur	19312	21238	25586	26993	34998	2.7	2.9	2.9	3.4	3.7
Meghalaya			28031	16441	18172			3.7	3.3	3.3
Rajasthan	11112	11941	18467	10742	11068	9.1	12.7	9.5	5.9	6.2
Tamil Nadu	3096	5395	6996	7537	6765	2.1	3.0	4.3	4.9	3.1
Uttarakhand	5569	5040	4646	10610	20858	2.9	2.0	2.7	4.3	102.6
All India	8580	9090	9674	8610	10122	3.1	3.3	4.0	3.8	4.8

Breakeven yield analysis revealed potential profit losses if yields and premiums are below the critical thresholds. Based on the cultivation cost and selling price of soybean, the break even yield was worked out and presented in Table 5. The results of analysis revealed that the breakeven yield, on an average basis, varied from 543 kg/ha Bihar to 1224 kg/ha in Karnataka under improved production technology. The overall average soybean yield needed to breakeven was 741 kg/ha to receive positive returns under improved soybean technology. However, in farmers practice, break even yield varied from nearly 350 kg/ha in Manipur and Meghalaya to more than 1000 kg/ha in Karnataka and Maharashtra with the average of 647 kg/ha at current market prices. The break even yield points *i.e.* 741 and 647 kg /ha indicated that these yield levels showed no profit no loss in soybean cultivation and for profitable soybean production yield should be higher than this break even yield. The results revealed that the break even yield level was higher under improved technology than farmers practice. Similar results were also reported in a study by Mayata *et al.,* (2014).

Table 5: Breakeven yield of soybean in different states of India

State	2013		2014		2015		2016		2017		Average	
	IT	FP	IT	FP	IT	FP	IT	FP	IT	FP	IT	FP
AP/ Telangana	958	790	911	792	913	778	1382	1136	1128	1006	1059	900
Bihar							654	601	649	606	652	604
Chhatisgarh	453	321	624	381	506	287	590	334			543	331
Gujarat	411	400	474	455	503	485	705	670	758	660	570	534
Himachal Pd	683	533	569	473	575	496	627	546	687	599	628	530
Jharkhand	644	464	683	496	618	446	814	643	767	633	705	536
Karnataka	1235	1124	1193	1050	1247	1141	1415	1284	1030	856	1224	1091
Madhya Pd	514	387	591	446	515	401	592	482	597	487	562	441
Maharashtra	941	816	1232	1213	922	899	1171	1223	1105	1142	1074	1059
Manipur	598	368	556	355	628	378	527	343	559	341	574	357
Meghalaya					552	379	468	348	510	376	510	367
Rajasthan	491	451	752	717	630	567	729	657	768	692	674	617
Tamil Nadu	625	551	754	677	824	764	817	762	855	764	775	704
Uttarakhand	504	400	850	677	483	390	727	689	919	893	697	610
All India	660	541	747	626	685	597	829	751	784	719	741	647

CONCLUSION

Careful recommended input selection and testing in the local environments and production systems are needed if farmers are to consider the adoption of soybean production technology at current market conditions. Also, as commodity prices fluctuate, additional breakeven analyses must be conducted to accurately estimate future profitability soybean production. Adequate testing will ensure optimal yields for the growers and desired soybean quality for the processors.

In summary, any yields above 741 and 647 kg/ha under improved soybean production technology and farmers practice for soybeans sold at harvest represented profitable income over breakeven prices. Achieving consistent production at these high levels without causing environmental damage requires improvements in soil quality and precise management of all production factors in time and space.

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