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Performance of Soybean Varieties under Frontline Demonstrations

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ABSTRACT

A total of 7,191 frontline demonstrations (FLDs) were organized on soybean across the country during 2011 to 2018 to assessthe yield gaps between improved soybean varieties (Nos 65) with improved package of practices (IP) and framers' practice (FP). The objective of the study was to assess the performance of improved varieties of soybean as compared to farmers' preferred varieties. Maximum number of FLDs (47 %) were conducted on variety JS 95-60. Of these 65 varieties, four of them (JS 95-60, JS 93-05, JS 335 and MAUS 58) represented 67 per cent of the demonstrations. The highest and lowest yielding ability of varieties KDS 344 and MAUS 71 respectively, was recorded under IP. The magnitude of yield variation between maximum and minimum was 236 per cent under IP. All the soybean varieties under IP led to enhanced yield between 7 per cent (JS 20-69) and 102 per cent (VLS 65) over FP. The cost of cultivation among the soybean varieties varied from Rs 15,520 and Rs 12,707 per ha (NRC 7) to Rs. 46,308 and Rs. 47,808 per ha (VLS 63) under IP and FP, respectively. The maximum net returns were achieved with the variety MACS 1460 [Rs 72,625 (IP) and 44,818 (FP)], while the minimum cost of cultivation (Rs 17,937/ha) was required for variety CO3 under IP and Rs. 8,399 per ha for NRC 86 under FP. Sustainable yield index (SYI) varied from 0.41 (CO3) to 0.95 (RKS 45) under IP, while it was from 0.35 (JS 20-34) to 0.92 (VLS 47) under FP. It indicated that the minimum guaranteed soybean yield varied from 41 to 95 per cent of the maximum yield in former and 35 to 95 per cent in later. Invariably varieties under IP showed higher SVI values than FP with reference to gross and net returns. The break-even yield (BEY) varied from 516 (NRC 7) to 1,464 kg per ha (VLS 63) with the mean of 795 kg per ha under IT, while it ranged from 377 (DSb 19) to 1,439 kg per ha (VLS 63) with the average of 698 kg per ha under FP. The break-even cost (BEC) oscillated between 7.38 (DS 228) and 39.53 Rs per kg (VLS Bhatt 201) with the mean of 15 kg per ha under IT, while it varied from 7.67 (DS 228) to 57.27 Rs per kg (VLS Bhatt 201) with an average of Rs 17 kg per ha under FP, which indicated a difference of 435.64 and 647 per cent, respectively.

Key words: Break-even yield, break-even cost, coefficient of variation, frontline demonstration, sustainable yield index, sustainable value index

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Soybean growing region is spread over in latitudinal belt of about 158^0N to 258^0N covering nearly 98 per cent of the total area in India. Soybean is predominantly grown on Vertisols and associated soils experiencing an average crop season rainfall of about 900 mm; which is varying greatly across locations and years. Introduction of soybean in these areas after 1970 has led to a shift in the cropping systems from rainy season fallow-post-rainy season (wheat/ chickpea) to soybean-wheat/chickpea, enhancing the cropping intensity and profitability per unit area of land. Besides improving the socio-economic conditions of small and marginal farmers in this region, the crop helped in meeting out 21 per cent of the total domestic edible oil production and earning foreign exchange of worth Rs.5459.50 million by exporting de-oiled cake in 2016-17 (DAC&FW, 2018). Despite a phenomenal growth in area and production, the average national productivity of soybean has remained more or less stagnated at 1,000 kg per ha due to several abiotic, biotic and socio-economic constraints (Paroda, 1999; Joshi and Bhatia, 2003; Bhatnagar and Joshi, 2004; Tiwari, 2014). Several studies (Aggarwal and Kalra, 1994; Lansigan *et al*., 1996; Evenson *et al*., 1997; Naab *et al*., 2004) have shown that assessment of potential yield and yield gaps can help in identifying the yield limiting factors and in developing suitable strategies to improve the productivity of soybean.

The frontline demonstrations (FLDs) programme sponsored by Ministry of Agriculture was executed under the close supervision of scientists of the National Agriculture Research System (NARS), wherein the improved technologies were demonstrated for the first time before being transferred to the main extension system of the State Department of Agriculture. These demonstrations were proved to be an effective tool to disseminate the latest developed research emanated technologies among the farming community (Gautam *et al*., 2007). These demonstrations have created greater awareness and motivated the respondents and other fellow farmers to adopt appropriate oilseed production technologies (Singh *et al*., 2014). The main objective of FLDs is to demonstrate the performance of newly released soybean varieties along with recommended package of practices including production and protection technologies in the farmers' field in different agro-climatic regions and farming situations.

METHODS AND MATERIAL

A total of 7,191 FLDs (each on 0.4 ha) on 65 soybean varieties along with improved package of practices (IP) were organized across the country during 2011 to 2018 which were compared with farmers' practice (FP). The seed of improved variety and critical inputs, as per norms, were supplied to the farmers to conduct the demonstrations. The yielding ability of soybean varieties was categorized in 5 yield groups (>2,500, 2,000-2,500, 1,500-2,000, 1,000-1,500 and >1,000 kg per ha). The performance of IP was assessed by comparing the yield and monetary advantages over FP. The

variety-wise sustainable yield index (SYI), sustainable value index (SVI) standard deviation and coefficient of variation were determined as per the standard procedures (Singh *et al.*, 1990). Break-even yield (BEY) and break-even cost (BEC) were determined as used by Dupare *et al*. (2019).

RESULTS AND DISCUSSION

Out of the 65 soybean varieties, the maximum number of FLDs were organized on JS 95-60 (47.05 %) followed by JS 93-05 (10.71 %), JS 335 (5.25 %), MAUS 158 (3.46 %), Hara soya (2.10 %) and RKS 18 (2.04 %) and rest (> 2%).

Yield variability

Soybean varieties exhibited differential yielding ability during the period of study. The maximum yield was recorded with KDS 736, which was closely followed by KDS 344, MACS 1281, DS 228 and MACS 1188, while the lowest yield was with MAUS 71. The magnitude of yield variation ranged between maximum and minimum was 236 per cent under IP. The maximum varieties (Table 1) were under yield category of 1,500-2,000 (50 %), followed by 1,000-1,500 (24 %), 2,000-2,500 (16 %), >2,500 (9%) kg per ha and minimum under less than 1,000 kg per ha (2%). Out of 65 varieties, 17 were demonstrated in only one year and hence other parameters were not worked out. The coefficient of variation indicated that the highest yield variability associated with variety Shivalik (38.57 %) and lowest with RKS 45 (3.29 %) under IP, while in case of farmers' practice, the maximum was with JS 20-34 (44.96 %) and minimum with VLS 63 (4.15 %) over the years. Out of 49 varieties, 10 varieties (MAUS 158, VLS 47, VLS 63, Pusa 97-12, RVS 2001-4, MAUS 612, PS 1042, PS 1368, DSb 1 and SL 688) showed higher yield variability under IP than FP. Five varieties (MAUS 162, NRC 7, MAUS 2, GJS 2 and Basar) showed more or less similar yield variability under both the conditions (IP and FP). Rest of the varieties showed lesser yield variability under IP as compared to FP.

All the soybean varieties under IP enhanced the yield by 7.13 (JS 20-69) to 101.79 per cent (VLS 65) over FP.

The results gain support from the findings reported by (Singh *et al*., 2019; Singh *et al*., 2018; Singh *et al*., 2007). The effective narrowing of yield gap due to popularization of improved varieties and technology through FLDs at farmers field has earlier been documented (Kumar and Meena, 2013; Raut *et al*., 2016).

Sustainable yield index (SYI)

Sustainable yield index (SYI) varied from 0.41 (CO3) to 0.95 (RKS 45) under IP, while it was 0.35 (JS 20-34) to 0.92 (VLS 47) under FP, which indicated that the minimum guaranteed soybean yield varied from 41 to 95 per cent of the maximum yield under IP and 35 to 95 per cent under FP (Table 2). Of the 65 soybean varieties, fourteen (RKS 18, MACS 1188, VLS 65, VLS 63, JS 97-52, MAUS 81, PS 1347, Pusa 97-12, SL 688, SL 525, SL744, PS 1042, PS 1368 and DSb 1) showed higher SYI under FP as compared to IP. While of nine varieties (Hara soya, VLS 47, CO3, NRC 7, MAUS 2, Himsoya, GJS 3, Basar and MAUS 612), both under IP and FP,

Table 1. Categorization of soybean varieties based on yield performance

Yield (kg/ha)	Variety	Coverage of varieties
2500-3000	DS 228, MACS 450, KDS 344, KDS 736, MACS 1281 and MACS 1188	9.09
2000-2500	PS 23, JS 20-69, PS 24, RKS 24, MACS 1460, Basar, VLS 59, MAUS 2, MAUS 81 and VLS 63	15.15
1500-2000	SL 688, RVS 2002-04, DS 228, DSb 1, RKS 113, MAUS 612, JS 20 98, Bragg, PS 1368, PUSA 12, RVS 24, PS 1042, PS 1225, DSb 19, SL 744, RKS 45, SL 525, GJS 3, Him soya, PUSA 97 12, PS 1347, SL 958, CO 3, JS 20 29, NRC 37, JS 20-34, JS 97-52, DSb 21, VLS 47, RKS 18, MAUS 158, JS 335 and JS 93-05	50.00
1000-1500	PS 1477, Shivalik, RVS 18, Palam soy, NRC 86, PS 1092, BSS 2, Ankur, RVS 2001-4, NRC 7, VLS 65, VL Bhatt 201, MAUS 162, Hara soya and JS 95 60	22.73
<1000	MAUS 71	1.52

Table 2. Categorization of varieties based-on sustainable yield index (SYI)

SYI	Variety	Percentage to total varieties
>0.90	VLS 47, GJS 3, RKS 45	6
0.80 to 0.90	RKS 18, KDS 344, VLS 63, VLS 59, Pusa 97 12, Basar, KDS 736, MACS 450, DSb 19, RVS 24, NRC 86	22
0.70 to 0.80	JS 95 60, JS 93 05, DSb 21, NRC 7, MACS 1188, SL 958, Him Soya, SL 525, SL 744, MACS 1281, PS 1225, PS 1042, MACS 1460, RKS 24	28
0.60 to 0.70	JS 335, Hara soya, NRC 37, VLS 65, MAUS 81, MAUS 2, MAUS 612, PS 1092, BSS 2, Bragg, SL 688	22
0.50 to 0.60	MAUS 156, JS 97 52, JS 20 29, PS 1347, RVS 2001-4, PS 1368, DSb 1	14
0.40 to 0.50	MAUS 162, JS 20 34, CO3, Shivalik,	8

behaved identical with reference to SYI. Rest of the varieties showed higher SYI values under IP than FP

Economic performance

The cost of cultivation of among the soybean varieties with improved production technologies varied from Rs 15,520 to Rs 12,707 per ha in case of NRC 7. It varied from Rs 46,308 to Rs 47,808per ha (VLS 63) under IP and FP, respectively. The highest gross returns was obtained from variety MACS 1460 (Rs 1,05,841 and Rs70,613/ha) under both the situations (IP and FP). However, the lowest gross returns were recorded from variety MAUS 71 (Rs 28,438/ha) under IP and variety RVS 2001-4 (Rs 25,786/ha) **u**nder FP (Data not shown). The maximum net returns were observed with the variety MACS 1460 (Rs 72,625 and Rs 44,818 under IP and FP, respectively), while the

minimum (Rs 17,937/ha) was obtained from variety CO3 under IP and Rs 8,399 per ha from NRC 86 under FP. The improved production technologies including improved soybean varieties gave higher B:C ratio than FP except in case ofsoybean varieties PS 1225, PS 1042, Bragg, Shivalik and PS 1368. The maximum B:C ratio was recorded from soybean variety JS 20-69 under IP (3.61) and FP (3.54). The lowest B:C ratio obtained from CO3 (1.44) under IP and from KDS 736 (1.00) under FP (Table 3).

The gross returns variability indicated that the improved practices showed higher variability than FP except in 13 varieties (MACS 158, VLS 47, DSb 21, JS 20-34, VLS 65, JS 20-29, VLS 59, RVS 2002-4, RKS 45, RVS 24, NRC 86, DSb1 and SL 688). Similarly, cost of cultivation under IP showed higher variability as compared to FP except in 9 varieties (MAUS 158, Hara soya, VLS 47, KDS 344, MACS 450, MAUS 612, MACS 1460, Bragg and Shivalik). In all 17 varieties (JS 93-05, MAUS 158, RKS 18, JS 20-34, JS 20-29, MAUS 2, Himsoya, RKS 45, SL 744, KDS 736, MAUS 612, PS 1092, RVS 24, MACS 1468, NRC 86, Bragg and SL 688) showed higher variability under FP with regards to net returns. Invariably variability in IP with reference to B:C ratio was found lower than FP except in 13 varieties (JS 335, RKS 18, MAUS 162, MAUS 2, Pusa 97-12, GJS 3, SL 525, RKS 45, KDS 736, DSb 19, BSS2, DSb1 and SL 688). Similar variations among varietal behavior were also stipulated by (Singh *et al*., 2019; Singh *et al*., 2018; Kirar *et al*., 2005 and Billore *et al*., 2004).

Sustainable value index (SVI)

Gross returns sustainable value index revealed that the maximum value was obtained from variety GJS 3 (0.95) under IP, where as it was highest from variety KDS 344 and PS 1042 (1.00) under FP (Table 3). However, the variety SL 688 showed the maximum SVI (0.98) under IP and the lowest was from variety DSb 21 (0.10) under FP. Invariably varieties under IP showed higher SYI values than FP with reference to gross returns except 12 varieties (RKS 18, JS 97-52, MACS 1188, PS 1347, Pusa 97-12, MAUS 612, PS 1225, MACS 1281, PS 1042, MACS 1460, PS 1368 and RKS 24). However, varieties namely JS 95-60, MAUS 162, NRC 7, CO3, MAUS 2, Himsoya, GJS 3, Basar and DSb 19 behaved more or less identically under IP and FP (local varieties). In case of net returns, varieties like RKS 18, JS 97-52, Pusa 9712, MACS 1281, BSS2, PS 1042, MACS 1460, PS 1368, RKS 24 and DSb1 indicated higher SVI under FP as compared to IP. Only 6 varieties, namely MACS 1188, PS 1347, Him soya, GJS 3, Basar and DSb 19 performed more or less similar SVI under both the situation(IP and FP) with regards to net returns. The planting of soybean improved varieties with IP showed lower variability in economic returns (gross and net returns) as compared to FP. However, few varieties like MAUS 162, NRC 7, CO3, MAUS 2,DSb 19, MACS 1281, Basar and BSS 2 showed more or less similar variability under IP and FP in terms of gross and net returns, respectively. Improved varieties namely, JS 335, RKS18, JS 97-52, PS 1347, GJS 3, SL 525, MACS1281, Basar, PS 1092, MACS 612, PS 1225, PS 1042, PS 1368, PS 1460 and RKS 24

Table 3. Economics of soybean varieties tested under frontline demonstrations

Variety	Net returns (Rs/ha)		B:C ratio		SVI		Variety	Net returns (Rs/ha)		B:C ratio		SVI	
	IP	FP	IP	FP	IP	FP		IP	FP	IP	FP	IP	FP
JS 95 60	29503	21708	2.76	2.51	0.61	0.57	MACS 1281	55796	43550	2.70	2.44	0.57	0.60
JS 93-05	28111	19085	2.22	2.02	0.54	0.40	Basar	40805	34442	2.23	2.22	0.81	0.81
JS 335	38931	24095	3.08	2.11	0.44	0.42	KDS 736	55685	37091	2.32	1.00	0.70	0.53
MAUS 158	24764	19434	1.81	1.66	0.58	0.43	MAUS 61-2	29980	24221	2.38	2.29	0.72	0.63
Hara Soya	31382	22727	2.31	2.29	0.76	0.70	Ankur	26359	-	2.06	-	-	-
RKS 18	39884	28727	2.53	2.43	0.43	0.47	MACS 450	36061	29731	2.16	2.05	0.40	0.31
MAUS 162	19513	13292	1.65	1.46	0.16	0.08	DSb 19	69795	44818	3.11	3.03	0.67	0.67
VLS 47	31723	18238	2.14	2.69	0.81	0.71	PS 1092	26517	21545	2.34	2.38	0.49	0.43
DSb 21	24640	16574	1.96	1.86	0.23	0.10	BSS 2	18747	12515	2.07	1.93	0.38	0.39
KDS 344	56005	35141	2.38	1.55	0.71	0.65	PS 1225	30213	24214	2.60	2.63	0.44	0.34
JS 97-52	35023	22201	2.84	2.72	0.43	0.46	PS 1042	32313	26830	2.67	2.73	0.25	0.31
VL Bhatt 201	40122	20240	1.80	1.41	-	-	MAUS 71	1669	109	1.06	1.00	-	-
JS 20-34	31435	20695	2.60	2.18	0.31	0.13	PS 1368	32751	27614	2.31	2.30	0.20	0.23
VLS 63	35333	13187	1.80	1.30	-	-	RVS 24	30287	17254	2.62	2.04	0.82	0.64
VLS 77	35028	20101	1.78	1.46	-	-	MACS 1460	72625	45465	3.18	2.98	0.48	0.70
NRC 37	36024	26163	2.96	2.56	0.32	0.28	Pusa 12	38665	29922	2.46	2.23	-	-
VLS 65	24740	18302	1.96	1.38	-	-	NRC 86	21433	8399	2.08	1.49	0.86	0.28
JS 20-29	35487	25357	2.74	2.36	0.46	0.29	Bragg	24219	19250	2.33	2.56	0.52	0.43
NRC 7	25808	18904	2.63	2.47	0.52	0.50	Palam soy	34749	22066	1.91	1.64	-	-
MACS 1188	50711	41131	2.62	2.47	0.65	0.65	RKS 24	40739	34469	3.38	3.28	0.87	0.92
CO3	17937	11555	1.62	1.44	0.75	0.65	JS 20 98	44394	35098	3.05	2.83	-	-
SL 958	37833	-	-	-	-	-	RKS 113	40897	35743	2.85	2.81	-	-
MAUS 81	34410	29362	2.69	2.73	0.31	0.26	DSb 1	37137	24174	3.37	2.86	0.54	0.79
MAUS 2	34197	28185	2.75	2.76	0.51	0.44	DS 228	38378	28037	2.90	2.80	-	-
PS 1347	34859	29305	2.82	2.94	0.44	0.43	RVS 2002 - 04	27536	12683	2.43	1.74	-	-
VLS 59	31708	15880	1.70	1.36	-	-	RVS 18	25136	11683	2.31	1.68	-	-
Pusa 97-12	41921	30424	2.65	2.29	0.70	0.79	PS 24	42908	25510	2.37	1.96	-	-
Him Soya	32587	23790	2.37	2.45	0.70	0.92	SL 688	17464	14954	2.21	2.06	0.98	0.76
GJS 3	23603	19577	2.25	2.11	0.90	0.91	Shivalik	20915	17288	2.17	2.41	0.47	0.32
SL 525	32142	16796	2.30	2.19	0.28	0.70	JS 20-69	57087	52733	3.61	3.51	-	-
RVS 2001-4	26040	9769	2.43	1.61	0.73	0.27	PS 23	38375	27697	2.23	2.04	-	-
RKS 45	33747	28381	2.61	2.50	0.94	0.86	PS 1477	14505	11481	1.51	1.45	-	-
SL744	24899	17615	2.30	2.17	0.54	0.38							

Table 4. Break-even yield (BEY) and break-even cost (BEC) of soybean varieties tested under frontline demonstrations

S No	Variety	BEY (kg/ha)		BEC (Rs/kg)		Incremental net returns (Rs/ha)	S No	Variety	Break even yield (kg/ha)		Break even cost (Rs/kg)		Incremental net returns (Rs/ha)
		IP	FP	IP	FP				IP	FP	IP	FP	
1	JS 95 60	548	470	11.65	12.56	7795	**34**	MACS 1281	1025	949	11.79	13.11	12246
2	JS 93 05	791	701	14.36	15.72	9026	**35**	Basar	1024	882	14.62	14.79	6363
3	JS 335	763	596	15.86	17.36	14836	**36**	KDS 736	1237	1146	14.67	17.45	18594
4	MAUS 158	970	927	17.35	18.81	5330	**37**	Ankur	712	-	17.01	-	-
5	Hara soy	673	556	17.38	18.73	8655	**38**	MACS 450	1087	971	12.67	13.37	6330
6	RKS 18	702	547	14.02	14.07	11157	**39**	DSb 19	566	377	19.09	19.27	24977
7	MAUS 162	891	845	19.64	22.12	6221	**40**	PS 1092	642	534	12.98	13.31	4972
8	VLS 47	1073	990	17.83	23.08	13485	**41**	BSS 2	619	480	14.28	15.41	6232
9	DSb 21	1144	1000	18.16	20.12	8066	**42**	MAUS 61 2	884	807	12.27	13.10	5759
10	KDS 344	1190	1092	14.35	17.53	20864	**43**	PS 1225	745	626	13.07	13.40	5999
11	JS 97 52	555	394	13.27	14.14	12822	**44**	PS 1042	681	574	12.33	12.35	5483
12	VLS bhatt 201	710	689	39.53	57.27	19882	**45**	MAUS 71	804	727	31.35	33.15	1560
13	JS 20 34	621	551	12.47	14.85	10740	**46**	RVS 24	623	552	11.44	14.68	13033
14	VLS 63	1464	1439	21.46	30.08	22146	**47**	MACS 1460	737	558	14.15	15.20	27160
15	VLS 77	1102	1065	23.09	28.07	14927	**48**	PUSA 12	658	606	16.39	18.17	8743
16	NRC37	569	497	11.66	13.38	9861	**49**	PS 1368	729	630	14.70	15.03	5137
17	VLS 65	1034	1067	32.57	66.68	6438	**50**	NRC 86	640	556	14.98	21.74	13034
18	JS 20 29	646	594	11.73	13.59	10130	**51**	Bragg	694	500	11.79	11.13	4969
19	NRC 7	516	422	11.30	12.09	6904	**52**	Palam soy	735	664	27.23	31.72	12683
20	MACS 1188	1016	927	12.02	12.91	9580	**53**	RKS 24	653	574	8.11	8.29	6270
21	CO3	948	856	19.01	21.34	6382	**54**	JS 20 98	639	566	11.14	12.01	9296
22	SL 958	840	-	14.73	-	37833	**55**	RKS 113	652	582	11.89	12.05	5154
23	MAUS 81	815	709	10.64	10.70	5048	**56**	DSb 1	691	565	10.25	12.07	12963
24	MAUS 2	730	637	9.75	9.83	6012	**57**	DS 228	940	725	7.38	7.67	10341
25	PS 1347	697	587	11.62	11.62	-	**58**	RVS 2002 4	640	569	12.33	17.20	14853
26	VLS 59	1388	1342	22.18	29.44	15828	**59**	RVS 18	640	569	13.00	17.82	13453
27	PUSA 97 12	637	592	15.12	17.51	11497	**60**	PS 24	921	785	14.35	17.38	17398
28	Him soy	689	558	16.62	17.66	8797	**61**	SL 688	821	793	8.14	8.78	2510
29	GJS 3	725	681	11.51	12.31	4026	**62**	Shivalik	645	481	13.43	12.66	3627
30	SL 525	740	487	11.60	8.28	15346	**63**	JS 20 69	646	619	9.40	9.66	4354
31	RVS 2001-4	486	428	15.37	18.54	16271	**64**	PS 23	921	785	15.28	16.69	10678
32	RKS 45	626	564	12.81	13.36	5366	**65**	PS 1477	934	836	20.21	21.02	3024
33	SL 744	778	562	11.68	8.46	7284		**Mean**	**795**	**698**	**15**	**17**	**10489**
								SD	**209**	**226**	**6**	**10**	**6529**

Table 5. Categorization of varieties based on break-even yield (BEY) and break-even cost (BEC)

Category	BEY		BEC		INR
	IP	FP	IP	FP	
<mean-SD	NRC 7, RVS 2001-4	JS 95- 60, JS 97- 52, NRC 7, RVS 2001-4, DSb 19	RKS 24, DS 228, SL 688	SL 744, SL 525, RKS 24, DSb 228, SL 688	MAUS 71, SL 688, Shivalik, PS 1477
Mean-SD	JS 95- 60, JS 93- 05, JS 335, JS 97- 52, Hara soy, RKS 18, VLS Bhatt 201, JS 20- 34, NRC 37, JS 20- 29, MAUS 2, PS 1347, Pusa 97- 12, Him soy, GJS 3, SL 525, RKS 45, SK 744, Ankur, DSb 19, PS 1092, BSS 2, PS 1225, PS 1042, RVS 24, MACS 1460, Pusa 12, PS 1368, NRC 86, Bragg, Palam soy, RKS 24, JS 20-98, RKS 113, DSb 1, RVS 2002-4, PS 24, Shivalik, JS 20- 69	JS 335, Hara soy, RKS 18, VLS Bhat 201, JS 20- 34, NRC 37, JS 20- 29, MAUS 2, PS 1347, Pusa 97- 12, Him soy, GJS 3, SL 525, RKS 45, SL 744, PS 1092,BSS 2, PS 1225, PS 1042, RVS 24, MACS 1460, Pusa 12, PS 1368, NRC 86, Bragg, Palamsoy, RKS 24, JS 20-98, RKS 113, DSb 1, Shivalik, JS 20- 69	JS 95- 60, JS 93- 05, RKS 18, KDS 344, JS 97- 52, JS 20- 34, NRC 37, JS 20- 29, NRC 7, MACS 1188, SL 958, MAUS 81, MAUS 2, PS 1347, GJS 3, SL 525, RKS 45, SL 744, MACS 1281,Basar, KDS 736, MACS 450, PS 1092, BSS 2, MAUS 61 2, PS 1225, PS 1042, RVS 24, MACS 1460, PS 1368, NRC 86, Bragg, Palam soy, RKS 24, JS 20-98, RKS 113, DSb 1, DS 228, RVS 2002-4, RVS 18, PS 24, SL 688, Shivalik, JS 20- 69	JS 95-60, JS 93- 05, RKS 18, JS 97-52, JS 20-34, NRC 7, JS 20-29, NRC 37, MACS 1188, MAUS 81, MAUS 2, PS 1347, GJS 3, RKS 45, MACS 1281, Basar, MACS 450, PS 1092, BSS 2, PS 1225, PS 1042, RVS 24, MACS 1460, PS 1368, Bragg, JS 20- 98, RKS 113, DSb 1, Shivalik, JS 20- 69	JS 95-60, JS 93-05, MAUS 158, Hara soy, MAUS 162, DSb 21,JS 20-34, NRC 37, VLS 65, JS 20-29, NRC 7, MACS 1188, CO 3, MAUS 81, MAUS 2, PS 1347, Basar, MACS 450, PS 1092, BSS 2, MAUS 61 2, PS 1225, PS 1042, Pusa12, PS 1368, Bragg, RKS 24, JS 20 98, RKS 113, JS 20-69, GJS 3, Hara soy, RKS 45, SL 744
Mean + SD	MAUS 158, MAUS 162, VLS 47, VLS 65, MACS 1188, CO3, SL 958, MAUS 81, MACS 1281, Basar, MACS 450, MAUS 61 2, MAUS 71, BSb 228, PS 24, SL 688, PS 23, PS 1477	JS 93 05, MAUS 162, CO3, MAUS 81, Basar, MAUS 61 2, MAUS 71, DSb 228, PS 24, SL 688, PS 23, PS 1477	JS 335, MAUS 158, Hara soy, MAUS 162, VLS 47, DSb 21, CO 3, Pusa 97-12, Him soy, Ankur, DSb 19, Pusa 12, JS 20-69, PS 1477	JS 335, MAUS 158, MAUS 162, VLS 47, DSb 21, KDS 344, CO 3, Pusa 97 12, Him soy, RVS 2001-4, DSb 19, Pusa 12, NRC 86, RVS 2002-4, RVS 18, PS 1477	JS 335, RKS 18, VLS 47, JS 97-52, JS 20-34, VLS 77, VLS 59, Pusa 97-12, RVS 2001-4, SL 525, MACS 1281, RVS 24, NRC 86, Palam soy, DSb 1, RVS 2002-4, RVS 18, PS 24, PS 23
>mean +SD	DSb 21, KDS 344, VLS 63, VLS 77,VLS 59, KDS 736	MAUS 158, VLS 47, DSb 21, KDS 344, VLS 63, VLS 77, VLS 65, VLS 59,MACS 1281, KDS 736, MACS 450	VLS Bhatt 201, VLS 63, VLS 77, VLS 65, VLS 59, MAUS 71, Palam soy	BLS Bhatt 201, VLS 63, VLS 65, VLS 59,VLS 77, MAUS 71, Palam soy	KDS 344, VLS Bhatt 201, VLS 63, SL 958, KDS 736, DSb 19, MACS 1460, PS 24

showed higher variability under IP than FP in terms of gross returns, while in case of net returns10 varieties (JS 335, RKS 18, JS 97 52, PS 1347, GJS 3, SL 525, PS 1042, PS 1368, RKS 24 and DSB 1 showed higher variability under IP as compared to FP.

Break-even yield (BEY) and cost (BEC) and economic performance

The categorization of varieties based on mean (±) standard deviation and less/more than (±) standard deviation, indicated that the maximum number of varieties belonged to the category mean–standard deviation followed by mean + standard deviation in case of BEY, BEC and incremental net returns.

The break-even yield (BEY) varied from 516 (NRC 7) to 1,464 kg per ha (VLS 63) with the mean of 795 kg per ha under IT (Table 4 and 5). The magnitude of difference between maximum and minimum BEY was observed to the tune of 183.72 per cent. However, BEY ranged between 377 (DSb 19) and 1,439 kg per ha (VLS 63) with the average of 698 kg per ha under FP which showed a difference of 281.70 per cent. The BEC ranged between 7.38 (DS 228) to 39.53 Rs per per kg (VLS Bhatt 201) with the mean of 15 kg per ha under IP, while it varied from 7.67 (DS 228) to 57.27 Rs per kg (VLS Bhatt 201) with an average of 17 Rs per kg under FP, which indicated a difference of 435.64 and 646.68 per cent, respectively (Table 3). The BEY of improved soybean varieties was found higher (13.90 %) than the local varieties used under FP. However, the BEC of improved varieties were lower (13.33 %) than the varieties used under FP. Similar variations were also recorded by Dupare *et al*. (2019). The incremental net returns ranged between Rs. 2,510 (SL 688) and Rs. 27,160 per ha (MACS 1460), which indicated a difference of 982.07 per cent (Table 3).The varieties were categorized based on standard deviation (Table 4).

On the basis of above results it could be concluded that the adoption of new soybean varieties along with improved soybean production technologies was found to be helpful in narrowing the yield gap and able to enhanced the income from soybean cultivation.

REFERENCES

Aggarwal P K and Kalra N. 1994. Simulating the effect of climatic factors, genotype, water and nitrogen availability on productivity of wheat: II. Climatically potential yields and optimal management strategies. *Field Crop Research* **38:** 93–103.

Bhatnagar P S and Joshi O P. 2004. Current status of soybean production and utilization in India. *In*: *Proceedings of VII World Soybean Research Conference, IV International Soybean Processing and Utilization Conference, III Congresso Mundial de Soja (Brazilian Soybean Congress)*, Embrapa Soybean, Londina, Brazil, pp. 26–37.

Billore S D, Joshi O P and Dupare B U. 2004. Impact of frontline demonstrations on augmenting the soybean (*Glycine max* L.) productivity. *Journal of Oilseeds Research* **21**: 352–3.

DAC&FW. 2018. *Presentation on Vegetable Oils vis-a-vis Soybean in India* (http://www.sopa.org/presentations_2018/Vegetable%20oils%20vis-a-vis%20Soybean%20in%20India.pdf

Dupare B U, Sharma Purushottam and Billore S D. 2019. Break-even soybean yield analysis under frontline demonstrations. *Indian Journal of Extension Education* **55**(1): 103-8.

Evenson R, Herdt R and Hossain M. 1997. *Rice Research in Asia: Progress and Priorities*. CAB International and IRRI, pp. 418.

Gautam U S, Paliwal D and Kumar N. 2007. Impact of frontline demonstration on soybean production to improved livelihood of farmers in Madhya Pradesh. *Compendium, 4th National Extension Education Congress*, pp. 139-40.

Joshi O P and Bhatia V S. 2003. Stress management in soybean. *In*: Singh H, Hegde D M (Eds.), *Souvenir. National Seminar on Stress Management in Oilseeds for Attaining Self-reliance in Vegetable Oils*. Indian Society of Oilseeds Research, Hyderabad, India, pp. 13–25.

Kirar B S, Mahajan S K, Nnashine R, Awasthi H K and Shukla R K.2005. Impact of technology practices on the productivity of soybean in frontline demonstration. *Indian Research Journal of Extension Education* **5**: 15-7.

Kumar Raj and Meena D S.2013. Soybean production sustainability in south eastern Rajasthan. *The Journal of Rural and Agricultural Research* **13**(2): 9-11.

Lansigan F P, Bouman B A M and Aggarwal P K. 1996. Yield gapsin selected rice-producing areas in the Philippines. *In*: Aggarwal P K, Lansigan F P, Thiyagarajan T M, Rubia E G (Eds.), *Towards Integration of Models in Rice Research. SAARP Research Proceedings,* Wegeningen and Los Bafios, pp. 11–18.

Naab J B, Singh P, Boote K J, Jones J W and Marfo K O. 2004. Using CROPGRO-Peanut model to quantify yield gaps in the Guinean Savanna zone of Ghana. *Agronomy Journal* **96:** 1231–42.

Paroda R S. 1999. Status of soybean research and developmentin India. *In*: Kauffman H E (Ed.), *Proceedings of VI World Soybean Research Conference, Chicago*, IL, USA, pp. 13–23.

Raut R L, Verma V K, Barpete R D and Jain Sanjay. 2016. Soybean yield gap analysis through frontline demonstration in Satpura Plateau of MadhyaPradesh. *International Journal of Environment, Agriculture and Biotechnology (IJEAB)* **1**(2): 122-4.

Singh A K, Agrawal S B, Kirar B S, Sharma T R, Rawat A and Khan M I. 2018. Impact of production technology on productivity and profitability of soybean under Kymore Plateau and Satpura hills Agro Climatic zone of Madhya Pradesh. *The Pharma Innovation Journal* **7**(10): 82-4.

Singh A K, Singh K C, Singh Y P and Singh D K.2014. Impact of frontline demonstration on adoption of improved practices of oilseed crops. *Indian Research Journal of Extension Education* **14** (3): 75-7.

Singh, R. P., Das, S. K., Bhasker Rao, W. M. and Reddy, M. N. 1990. *Towards sustainable dry land Agricultural Practices*. CRIDA, Hyderabad, pp. 1-106.

Singh S R K, Mishra A, Suryawanshi A and Shrivastava V. 2019. Effect of varietal intervention on the yield of soybean crop across agro-climatic zones in Madhya Pradesh: A cluster approach. *Journal of Pharmacognosy and Phytochemistry* **8**(2): 408-10.

Singh T, Vyas M D, Saxena A and Jain A. 2007. Impact of new technologies on soybean at farmers field. *Indian Research Journal of Extension Education* **7**(1): 38-9.

Tiwari S P. 2014. Raising the yield ceilings in soybean – An Indian overview. *Soybean Research* **12**(2): 1-43.