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Productivity, Profitability and Monetary Net Return Use Efficiency of Need based Soybean (*Glycine max*) Cropping Systems under *Vertisols* in Malwa Plateau of India

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ABSTRACT

Background: Long term regular practice of soybean-chickpea and soybean-wheat system in the growing region is posing severe problems before the growers such as low productivity, profitability and monetary net return use efficiency due to delayed sowing of wheat and low market value of produce as well as poor economic viability of this cropping system.

Methods: A field trial was laid out during monsoon (rainy), winter and late winter seasons of the year 2015-16 and 2016-17 to evaluate the productivity, cost benefit and sustainability of soybean based crop sequences under Vertisols for Malwa Plateau at the experimental field of Krishi Vigyan Kendra, Dhar, Madhya Pradesh in Central India. In 16 cropping sequences, soybean was sequenced with feasible winter crops *viz.* wheat, chickpea, garlic, onion, potato and garden pea with inclusion of garlic, onion in late winter and assessed in randomized block design with four replications.

Result: Soybean (JS 93-05) - potato (Kufri jyoti) - onion (AFLR) cropping sequence registered the highest soybean equivalent yield (17731 kg/ha) with maximum gross returns (` 4,83,207/ha), net returns (` 3,62,170/ha), benefit: cost ratio (4.0) and monetary return use efficiency (per day return) (1156.01). Next highest soybean equivalent yield (10443 kg/ha) with maximum gross returns ` 2,83,337/ha, net returns ` 2,07,562/ha, benefit: cost ratio 3.74 and monetary return use efficiency (879.81) was recorded in soybean (JS 93-05) - onion (AFLR) cropping sequence than existing cropping sequences (soybean-wheat and soybean-chick pea).

Key words: Economics, Monetary return use efficiency, Soybean equivalent yield, Soybean-based cropping systems.

INTRODUCTION

Soybean [*Glycine max* (L.) Merrill] is a major legume crop having two major quality characters *viz.* protein and oil. Soybean is known as 'miracle bean' rich in protein (40%) and moderate in oil (18-22%) with balanced amino acid (FAO, 1982). Soybean is a high valued and profitable crop. In India, it is grown on an area of about 12.09 million hectares, which is likely to produce more than 11.22 million tonnes with productivity 928 kg/ha during the year 2020-21 (Anonymous, 2021). In order to that, Madhya Pradesh (6.19 million hectare), Maharashtra (4.04 million hectare) and Rajasthan (1.12 million hectare) constitute the major niche for the cultivation of soybean crop. Soybean is not only an important pulse crop but also known as oilseed crop in Central India.

Soybean and wheat/chickpea are most productive crops and predominantly grown in a sequential cropping, particularly under irrigated/rainfed cropping production system in almost periphery of Malwa region and Nimar Valley zone of India. Generally, growing of soybean and wheat in a cropping sequence are nutrients exhaustive and required heavy cost of cultivation in desirable agricultural practices during its cultivation. Long term regular practice of soybean-chickpea and soybean-wheat system in the growing region is posing severe problems before the growers such as complexity in weed management, deterioration of soil-properties, delayed sowing of wheat and low market value of produce owing low productivity as well as poor economic viability of this cropping system.

All domestic demands of the farmers pertaining to agricultural produce could not be possible to fulfill by growing crops in existing soybean-wheat/chickpea cropping systems. The socio-economic status of the growers connected with prevailing soybean based cropping sequences in the region

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is fairly less. Thus, the diversification and intensification of various crops under soybean based cropping sequences is a possible way for increasing the productivity and profitability per unit area per year without deteriorating the soil fertility and existing cropping sequence needs to be evaluated to meet the domestic need of farmers. The land and water use efficiency and employment opportunities can be enhanced with diversification and intensification of soybean based cropping systems with minimization of cultivation risks.

MATERIALS AND METHODS

A field experiment was laid out during *rainy, winter* and *late winter* seasons of 2015-16 and 2016-17 at the research farm of Krishi Vigyan Kendra, Dhar, Madhya Pradesh. It belongs to "Malwa Plateau" under 10th agroclimatic zone of Central India. Temperature varies between a minimum temperature of 12°C in December and January and maximum temperature of 45°C in May and June however normal annual rainfall is 830 mm. The soil of the experimental site was clay loam in texture, pH 7.60 with normal Electrical Conductivity (0.58 dS/m) and medium organic carbon content *i.e.* 0.59%. The experimental field was analysed and found values of major available nutrients *i.e.* N (236 kg/ha) low in available, P (11.60 kg/ha) medium in available and K (350 kg/ha) high in available contents. In these 16 cropping sequences, soybean was sequenced with feasible *winter* crops *viz*. wheat (*Triticum aestivum* and *Triticum durum* L.), chick pea (*Cicer arietinum* L.), garlic (*Allium sativum* L.*),* onion (*Allium cepa* L.), potato (*Solanum tuberosum* L.) and garden pea (*Pisum sativum* L.) with inclusion of garlic (*Allium sativum* L.*),* onion (*Allium cepa* L.) in *late winter* and tested in randomized block design with 4 replications.

Only soybean was grown during rainy season with two varieties *i.e.* JS 95-60 early duration (82-87 days) and JS 93-05 medium duration (90-95 days) under all cropping sequences. The amount of precipitation was 938.2 and 1103.51 mm during the year 2015-16 and 2016-17, respectively. Different varieties as per their feasibility to accommodate the succeeding crop under present investigation were cultivated under different need based diversified cropping sequences. The variety used for winter crops was like wheat (HI-1544) aestivum, wheat (HI-8663) durum, chickpea (JG-130) *desi*, chickpea (RVKG-101) *kabuli*, Potato (Kufri jyoti), garden pea (Arkel) and garlic (G-282) and onion (AFLR) during *late winter*, respectively. Sowing of rainy, winter and *late* winter season crops were done on 21.06.15 and 26.06.16; 17.10.15 and 21.10.16; and 02.01.16 and 03.01.17 during two consecutive years, respectively. The recommended dose of N:P:K (kg/ha) for soybean 20:80:20, wheat 120:60:40, chick pea 20:60:20, garlic 100:50:50, onion 100:75:50, potato 120:50:100 and garden pea 20:60:20 was applied. The observations of experiment were recorded as p er standard procedure. The experimental data was statistically analysed given by Gomez and Gomez (1984). The differences among treatments were calculated by using 'F' test and critically differences at 5% probability.

The methods of calculation of various cropping system indices with their references are as follows:

Soybean equivalent yield (SEY)

It was estimated by converting of prevailing market prices of grain yield of different crop components in every sixteen cropping sequences as suggested by Yadav and Newaj (1990). After this, soybean equivalent yield of all crops in a respective cropping sequence was summed up and further the values of soybean equivalent yield of all treatments were analysed statistically.

Soybean equivalent yield (kg/ha)=

$$\frac{\text{Yield of a crop (kg/ha)} \times \text{Price of yield (`/kg)}}{\text{Price of soybean yield (`/kg)}}$$

Economics of the treatments

Economics of different treatments was estimated as per government rates of the production and the cost involved in various cultural operations and inputs cost including labourers required for each treatment combination and the gross monetary returns (GMR) was also estimated from the production of the same treatment and prevailing market rate in the area.

NMR (`/ha/year) of a respective treatment=

$$\frac{\text{GMR (`/ha/year) of a treatment-cost of cultivation}}{\text{(`/ha/year) under the same treatment}}$$

Benefit cost ratio or profitability is the index indicating monetary gains over each rupee investment under different treatments. It is determined by formula given below:

$$\text{Benefit cost ratio} = \frac{\text{GMR (`/ha/year)}}{\text{Cost of cultivation (`/ha/year)}}$$

Monetary return use efficiency (Per day return)

Monetary return use efficiency is also known as income per day. It provides the efficiency of the cropping system or monetary value and obtained by using the formula given below:

$$\text{Per day return (`/ha/day)} = \frac{\text{Net returns}}{\text{Cropping period (days)}}$$

Soybean, *winter* crops *viz*.wheat, chick pea, garlic, onion, potato and garden pea and late *winter* crops *viz*. were harvested on 07.10.2015 and 09.10.2016; 20.02.2016 and 23.02.2017; 11.05.2016 and 21.05.2017 during two consecutive years, respectively. All the observations of experiment recorded as per standard procedure. The experimental data was statistically analysed given by Panse and Sukhatme (1985). The treatment differences were tested by using 'F' test and critically differences at 5% probability.

RESULTS AND DISCUSSION

Soybean yield equivalent (SEY)

A perusal of data revealed that soybean yield equivalent of cropping system as a whole, T_{15} - soybean (JS 93-05)-potato (Kufri jyoti)-onion (AFLR) system was recorded significantly maximum SEYs (17731 kg/ha) among all crop-sequences mainly due to greater SEY of potato during *winter* along with considering good SEYs of onion in *late winter* season. Closely followed by T_7 - soybean (JS 95-60)-potato (Kufri jyoti)-onion (AFLR) with regard to SEYs (17318 kg/ha). The next best crop sequence was soybean (JS 93-05)-onion (AFLR) recorded greater SEY 10443 kg/ha in T_{14} cropping sequences (Table 2). It might be due to higher yield of onion in the sequence. Further, the results revealed that there is sufficient scope to intensify the existing cropping sequence and increase in cropping sequence productivity with inclusion of onion and garlic during *late winter* while the minimum productivity of the cropping sequence based on SEYs was registered in soybean (JS 95-60) - chickpea (JG-130) desi *i.e.* 4279 kg/ha. This could be ascribed due to low yield realized from local chickpea in the sequence (Table 1).

Table 1: Mean economic yield (kg/ha) in different seasons under various crop sequences.

Crop sequences		Rainy			Winter			Late winter		
		2015-16	2016-17	Mean	2015-16	2016-17	Mean	2015-16	2016-17	Mean
T_1	Soybean-Wheat aestivum	1841	1960	1901	4583	4930	4757	-	-	-
T_2	Soybean-Wheat durum	1848	1987	1918	4940	5305	5123	-	-	-
T_3	Soybean-Chickpea desi	1881	2011	1946	1580	1695	1638	-	-	-
T_4	Soybean-Chickpea Kabuli	1905	1903	1904	1723	1868	1796	-	-	-
T_5	Soybean-Garlic	1937	2013	1975	8343	8475	8409	-	-	-
T_6	Soybean-Onion	1930	2022	1976	21400	22618	22009	-	-	-
T_7	Soybean-Potato-Onion	1958	2078	2018	17968	19415	18692	18556	19260	18908
T_8	Soybean-Garden pea-Garlic	2002	2046	2024	1106	1258	1209	6840	7175	7008
T_9	Soybean-Wheat aestivum	2043	2125	2084	4788	4773	4781	-	-	-
T_{10}	Soybean-Wheat durum	2017	2108	2063	5123	5173	5148	-	-	-
T_{11}	Soybean-Chickpea desi	1969	2144	2057	1690	1730	1710	-	-	-
T_{12}	Soybean-Chickpea Kabuli	1941	2135	2038	1865	1971	1918	-	-	-
T_{13}	Soybean-Garlic	2004	2233	2119	8590	8680	8635	-	-	-
T_{14}	Soybean-Onion	2031	2285	2158	21780	22850	22315	-	-	-
T_{15}	Soybean-Potato-Onion	1967	229	2129	18250	19830	19040	19348	19785	19567
T_{16}	Soybean-Garden pea-Garlic	2065	2248	2157	1230	1325	1278	7065	7360	7213

Table 2: Soybean equivalent yield in different seasons under various crop sequences (Pooled data of two years).

Crop sequences		SEY (kg/ha)			
		Rainy	Winter	Late winter	Total SEY
T_1	Soybean-Wheat aestivum	1901	3009	-	4909
T_2	Soybean-Wheat durum	1918	3200	-	5117
T_3	Soybean-Chickpea desi	1946	2333	-	4279
T_4	Soybean-Chickpea Kabuli	1904	2879	-	4783
T_5	Soybean-Garlic	1975	6229	-	8204
T_6	Soybean-Onion	1976	8152	-	10128
T_7	Soybean-Potato-Onion	2018	8308	7003	17329
T_8	Soybean-Garden pea-Garlic	2024	1791	5191	9006
T_9	Soybean-Wheat aestivum	2084	3200	-	5284
T_{10}	Soybean-Wheat durum	2063	3370	-	5433
T_{11}	Soybean-Chickpea desi	2057	2425	-	4482
T_{12}	Soybean-Chickpea Kabuli	2038	2950	-	4988
T_{13}	Soybean-Garlic	2119	6300	-	8419
T_{14}	Soybean-Onion	2158	8335	-	10493
T_{15}	Soybean-Potato-Onion	2129	8356	7247	17731
T_{16}	Soybean-Garden pea-Garlic	2157	1845	5343	9344
	SEm±	55	216	67	112
	CD (P=0.05)	156	618	192	315

Table 3 : Economics of soybean based different crop- sequences.

Crop sequences		Cost of cultivation	Gross monetary return (`/ha)			Net monetary return (`/ha)			B:C ratio		
			2015-16	2016-17	Pooled	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled
T_1	Soybean-Wheat aestivum	45100	132074	139859	135967	86974	94009	90492	2.93	3.05	2.99
T_2	Soybean-Wheat durum	45200	136871	145413	141142	91671	99763	95717	3.03	3.19	3.11
T_3	Soybean-Chickpea desi	41500	114553	120894	117724	73053	78594	75824	2.76	2.86	2.81
T_4	Soybean-Chickpea Kabuli	42000	128128	136326	132227	86128	93551	89840	3.05	3.19	3.12
T_5	Soybean-Garlic	70700	220253	225578	222916	149553	154578	152066	3.12	3.18	3.15
T_6	Soybean-Onion	75200	267403	282338	274871	192203	206513	199358	3.56	3.72	3.64
T_7	Soybean-Potato - Onion	120900	454826	481668	468247	333926	360593	347260	3.76	3.98	3.87
T_8	Soybean-Garden pea - Garlic	79900	236603	249888	243246	156703	169313	163008	2.96	3.10	3.03
T_9	Soybean-Wheat aestivum	45100	140437	148504	144471	95337	102629	98983	3.11	3.24	3.18
T_{10}	Soybean-Wheat durum	45300	145234	154058	149646	99934	107858	103896	3.21	3.34	3.27
T_{11}	Soybean-Chickpea desi	41500	122916	129539	126228	81416	87114	84265	2.96	3.05	3.01
T_{12}	Soybean-Chickpea Kabuli	42000	136491	145471	140981	94491	102521	98506	3.25	3.39	3.32
T_{13}	Soybean-Garlic	70700	228616	234223	231420	157916	162673	160295	3.23	3.27	3.25
T_{14}	Soybean-Onion	75200	275766	290908	283337	200566	214558	207562	3.67	3.81	3.74
T_{15}	Soybean-Potato-Onion	120700	470851	495563	483207	350151	374188	362170	3.90	4.08	4.00
T_{16}	Soybean-Garden pea-Garlic	80000	249466	262233	255850	169466	178858	174162	3.12	3.15	3.13
	SEm±	230	1617	2931	1674	1653	2951	1691	0.04	0.04	0.03
	CD (P=0.05)	658	4621	8377	4687	4724	8434	4736	0.10	0.13	0.08

Value of soybean, wheat, chickpea (desi), chickpea (kabuli), garlic, onion, potato, garden pea was ` 2700, 1500, 3500, 4000, 2000, 1000, 1200, 4000 and value of straw of soybean, wheat and chick pea was ` 180, ` 150 and ` 250 per quintal respectively. (Values on the basis of market price during 2016-17).

Table 4: Monetary net return use efficiency (`/ha/day) of different crop- sequences.

Crop sequences		Monetary net return use efficiency (`/ha/day)		
		2015-16	2016-17	Pooled
T_1	Soybean-Wheat aestivum	414.16	434.67	424.42
T_2	Soybean-Wheat durum	429.91	453.00	441.46
T_3	Soybean-Chickpea desi	344.59	367.87	356.23
T_4	Soybean-Chickpea Kabuli	430.64	449.41	440.03
T_5	Soybean-Garlic	639.12	634.75	636.94
T_6	Soybean-Onion	843.00	866.37	854.69
T_7	Soybean-Potato-Onion	1116.64	1153.25	1134.95
T_8	Soybean-Garden pea-Garlic	561.66	590.24	575.95
T_9	Soybean-Wheat aestivum	441.38	465.78	453.58
T_{10}	Soybean-Wheat durum	460.53	485.53	473.03
T_{11}	Soybean-Chickpea desi	402.21	390.66	396.44
T_{12}	Soybean-Chickpea Kabuli	458.69	481.26	469.98
T_{13}	Soybean-Garlic	666.31	662.04	664.18
T_{14}	Soybean-Onion	868.25	891.36	879.81
T_{15}	Soybean-Potato-Onion	1140.56	1171.45	1156.01
T_{16}	Soybean-Garden pea-Garlic	594.97	622.30	608.64
	SEm±	16.12	13.44	10.49
	CD (P=0.05)	46.08	38.41	29.38

Similar results were reported by Billore *et al.* (2013); Kumar and Kushwaha (2020); Narolia *et al.* (2018) and Prajapat, *et al.* (2014).

Economics (Profitability)

Data showed that all diversified intensive crop-sequences registered significantly greater GMR and NMR than prevailing crop-sequences *viz.* soybean-wheat/chickpea systems. The treatment (T_{15})- soybean (JS 93-05) - potato (Kufri jyoti)-onion (AFLR) fetched maximum GMR of ` 4,83,207/ha and NMR of ` 3,62,170/ha closely followed by T_7-soybean (JS 95-60)-potato (Kufri jyoti) - onion (AFLR) GMR of ` 4,68,247/ha and NMR of ` 3,47,260/ha among all crop sequences mainly due to high production potential of entire cropping system over existing crop sequences *viz.* T_1 with NMR of ` 90,492/ha and $T_3$ with NMR of (` 75,824/ha). Based upon above facts, the farmers have choice to select any suitable cropping system depending on their investment capacity (Table 3).

The significant maximum profitability (4.00) was noted with T_{15}- soybean - potato - onion cropping system closely followed by T_{14}-soybean-onion system considerably greater B:C (3.74) ratio than existing cropping sequences *viz.* T_1 (2.99) and T_3 (2.81). Almost whole crop sequences under present study had profitability more than 3.0 except to soybean-chickpea and soybean-wheat cropping system, which registered minimum profitability (2.81 to 2.99) index (Table 3). Economics in terms of profitability mainly attributed to such variations in GMRs, NMRs and B:C ratio of different cropping systems agreeing with views of Billore *et al.* (2013); Jugnahake *et al.,* 2018; Kumar and Kushwaha (2020) and Prajapat *et al.* (2014).

Monetary net return use efficiency (` /ha/day)

Data revealed that among all 16 diversified intensive crop sequences, T_{15}- soybean-potato-onion significantly fetched maximum (¹ 1156.1/ha/day) monetary value closely followed by T_{14}-soybean-onion (¹ 879.81/ha/day). The another best crop sequence was T_{13}- soybean (JS 93-05) - garlic (G-282) (` 664.18/ha/day) and $T_{16}$- soybean (JS 93-05) - garden pea - garlic (` 608.64/ha/day) as compared to both existing and traditional cropping sequences of the locality *viz.* T_{11}- soybean - chickpea desi (` 396.44/ha/day) and $T_3$- soybean - chickpea desi (` 356.23/ha/day). Differences among all these treatments were found significant (Table 4). Similar results were reported by Jugnahake *et al.,* 2018; Kumar and Kushwaha (2020); Narkhede *et al.* (2011); Narolia *et al.* (2018); Prajapat *et al.* (2014) and Ramesh *et al* (2009).

CONCLUSION

It is concluded that the treatment T_{15} - soybean (JS 93-05) - potato (Kufri jyoti) - onion (AFLR) cropping sequence registered the highest soybean equivalent yield (17731 kg/ha) in terms of system productivity with maximum gross returns (` 4,83,207/ha), net returns (` 3,62,170/ha), benefit: cost ratio (4.0) and monetary return use efficiency (per day return) (1156.01). Next highest productivity (17318 kg/ha) with maximum gross returns (` 4,68247/ha), net returns (` 347260/ha), benefit: cost ratio (3.87) and monetary return use efficiency (per day return) (1134.95) was recorded in soybean (JS 95-60) - potato (Kufri jyoti) - onion (AFLR) which was closely followed by soybean (JS 93-05) - onion (AFLR) cropping sequence in which soybean-equivalent yield of 10443 kg/ha, maximum gross returns ` 2,83,337/ha, net

returns ` 2,07,562/ha, benefit: cost ratio 3.74 and monetary return use efficiency (879.81) was recorded over prevailing cropping sequences (soybean-wheat and soybean-chick pea). The minimum SEYs 4279 kg/ha with GMR of ` 1,17,724/ha, NMR of ` 75,824/ha, B:C ratio (2.81) and monetary net return use efficiency (` 356.23/ha/day) were recorded in T_3-soybean (JS 95-60)-chickpea (JG-130).

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Conflict of interest

All authors declared that there is no conflict of interest.

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