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Productivity of Diversified Soybean [*Glycine max* (L.) Merrill] based Cropping Systems in Malwa Plateau of Madhya Pradesh, India

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A B S T R A C T

A field experiment was conducted to study effect of soybean [*Glycine max* (L.) Merrill] based cropping systems on biomass production in *Vertisols* of Madhya Pradesh during *kharif, rabi* and *zaid* seasons of 2015-16 and 2016-17 at the research farm of Krishi Vigyan Kendra, Dhar, M.P. Soybean crop was sequenced with feasible *rabi* 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.) crops with inclusion of Garlic (*Allium sativum* L.), Onion (*Allium cepa* L.) in *zaid* and tested in randomized block design with four replications. Inclusion of Garlic (*Allium sativum* L.) and Onion (*Allium cepa* L.) during *zaid* significantly increased the soybean-equivalent yield. Soybean (JS 93-05) - Potato (Kufri jyoti) - Onion (AFLR) cropping sequence significantly recorded the highest productivity (172.15 and 182.47 q/ha, respectively) during both the years in terms of soybean-equivalent yield. Next highest system productivity in terms of soybean-equivalent yield was significantly recorded in Soybean (JS 95-60) - Potato (Kufri jyoti) - Onion (AFLR) with 168.17 and 178.20 q/ha and Soybean (JS 93-05) - Onion (AFLR) (100.81 and 108.05 q/ha) cropping sequence during both years as compared to existing cropping sequences *i.e.* Soybean-wheat (47.55 q/ha) and soybean-chick pea (41.46 q/ha) of the locality.

Introduction

Soybean [*Glycine max* (L.) Merrill] is a major legume crop recognized as the efficient producer of the two scarce quality characters *i.e.* the protein and oil, which are not only the major components in the diet of vegetarians mass but a boon to the developing countries as well. Due to short growing season, soybean fits well in a number of cropping systems and is well suited for intercropping with a number of crops resulting in better land equivalent ratio and helps in the risk aversion due to climatic uncertainties in rainfed conditions. Generally, soybean is grown as a monsoon season crop under rainfed situation mainly under *Vertisols* and associated soils. It has resulted increased cropping intensity and

profitability.

In Malwa and Nimar valley region, its cultivation is largely practiced in rainy season followed by Gram/wheat on conserved soil moisture. Under irrigated conditions, soybean is largely grown in soybean-wheat cropping system, while soybean-chickpea cropping system is prevalent under rainfed conditions. The major cropping system in the *Vertisols* and associated soils of Central India under regime is soybean-wheat in which soybean is a rainfed crop. Both soybean and wheat are most productive crops and predominantly grown in a sequential cropping, particularly under irrigated production system in *Vertisols* of Madhya Pradesh. Soybean-chickpea system is also prevalent as a next important cropping sequence mainly in those areas, where rainfall is not adequate or irrigation water is scarce. Generally, cultivation of both Soybean and wheat in a sequence are nutrients exhaustive and these crops require heavy investment in desirable agricultural operations during their 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/gram cropping systems. The market values of soybean and wheat are comparatively low than pulses, oilseeds and vegetable crops. Therefore, the purchasing capacity of the farmers to meet out their demands of vegetables, fruits, edible oil and pulses declines from the value realized by the produce of soybean and wheat crops. Under such circumstances, the diversification of existing soybean -wheat/chickpea system needs to be evaluated to meet the domestic need of farmers. Simultaneously, the economic status of the farmers of Soybean-wheat growing areas will also be raised by replacing any of the two crop components with the introduction of high value crop without degrading the land-resources. Consequent upon above facts, evaluation of suitable diversified cropping system under existing agro-ecological and farming situation needs to be identified through proper investigation.

Therefore socio-economic status of the farmers associated with prevailing soybean based cropping systems in the region is quite low. Since the number of crops being grown during rabi season in district Dhar of Malwa region is relatively more than other districts, though in relatively smaller area e.g. chickpea, garlic, onion, potato, garden pea etc. Under such circumstances, the diversification of crops under soybean based cropping system appears to be a possible way for improving the productivity and profitability per unit area per year without jeopardizing the soil health. Hence, diversification of cropping system is necessary to get higher yield, maintain soil health, preserve environment and meet daily food and fodder requirement of human and animals.

Materials and Methods

A field experiment was conducted for two years during *kharif*, *rabi* and *zaid* seasons of 2015-16 and 2016-17 at Research Farm of Krishi Vigyan Kendra, Dhar (M.P.) to study "effect of soybean [*Glycine max* (L.) Merrill] based cropping systems on biomass production in *Vertisols* of Madhya Pradesh". Dhar district belongs to "Malwa Plateau" under 10th agroclimatic zone of Madhya Pradesh. The soil of the field was a typical

medium black soil. Due to dominance of Montmorillonite, clay content it has high capacity to swell and shrink and high CEC. The soil of the experimental field was clay loam in texture, neutral in reaction (pH 7.60) with normal EC (0.59 dS/m) and low organic carbon contents (0.53%) and low in available N (218 kg/ha), medium in available P (11.60 kg/ha) and high in available K (350 kg/ha) contents. The experiment comprised 16 cropping sequences, soybean was sequenced with feasible *rabi* viz. Wheat (*Triticum aestivum* & *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 *zaid* and tested in randomized block design with four replications.

Only soybean crop was grown during *kharif* season with two varieties i.e. JS 95-60 (82-87 days) and JS 93-05 (90-95 days) under all crop- sequences, Different varieties were grown under various need based diversified intensive crop sequences as per their feasibility to accommodate the succeeding crop under present investigation, The variety used for rabi 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 zaid, respectively. Sowing of *kharif, rabi* and *zaid* crops were done in second week of June, October and February, respectively.

Sowing of different crops under different crop sequences was done as per recommended package of practices for crops under irrigated condition. The cropping sequences were evaluated in terms of seed and straw soybean-equivalent yield.

$$\text{Seed soybean equivalent yield (q/ha)} = \frac{\text{Grain/tuber/bulb yield of a crop (q/ha)} \times \text{Price of yield (₹ /q)}}{\text{Price of soybean yield (₹ /q)}}$$

$$\text{Straw Soybean equivalent yield (q/ha)} = \frac{\text{Straw/haulm yield of a crop (q/ha)} \times \text{Price of straw (₹ /q)}}{\text{Price of soybean straw (₹ /q)}}$$

Results and Discussion

Data recorded on various observations during the two consecutive years of investigation were tabulated and then subjected to their statistical analysis. Different crops were grown in the field under 16 crop sequences during different cropping seasons. During *Kharif Season,* only Soybean was grown under all the 16 crop sequences and different crops were grown in these crop-sequences during *Rabi* and *Zaid* seasons in succession to Soybean and thereafter. Therefore, statistical analysis of data pertaining to growth and yield parameters and economic yield of these successive crops were not possible. The data determined for the evaluation of relative performance of various crop sequences as a whole in terms of combined yields/system productivity (soybean equivalent yield) were recorded and statistically calculated (Table 1–3).

Crop productivity

Studies on *Kharif* season crop

Only Soybean crop was grown during *Kharif* season with two varieties *i.e.* one variety JS 95-60 early duration (82-87 days) and second variety JS 93-05 medium duration (90-95 days) under all crop- sequences, Different varieties were grown under various need based diversified intensive crop sequences as per their feasibility to accommodate the succeeding crop under present investigation,

The Soybean varieties tested under study were JS 95-60 (a high yielder widely accepted by the farmers in the locality), JS 93-05 (a medium duration high yielding). Relative performance of these varieties under different treatments in terms of their yield attributing characters and grain as well as straw yields are described below in suitable heads:-

It is evident from the data that average numbers of branches per plant were increased with increase in the age of the Soybean crop till 60 DAS. It is clearly evidenced from the data that the rate of increase in number of branches was found maximum between 45 and 60 days after sowing in both varieties. Data revealed that there was no significant difference in number of branches per plant at all the growth stages in both varieties. Based on 2 years data, Maximum and minimum number of branches per plant were 3.7 to 3.3 in JS 95-60 and 4.2 to 3.5 in JS 93-05 was recorded during 2016-17

The number of pods per plant is one of the important yield contributing characters which determine the grain yield of soybean crop. Number of pods per plant directly affects the number of grains per plant and ultimately the final grain yield. Based on 2 years data, the maximum number of pods was 43.20 in JS 95-60 while the maximum number of pods was 47.50 in JS 93-05. The minimum number of pods was 36.80 in JS 95-60 while the minimum number of pods was 38.90 in JS 93-05 during 2016-17.

The number of seeds per pod is one of the important yield attributing characters which directly affects the yield of the crop. Data showed that the there was a variation in seeds per pod but statistically it was non-significant. However, the maximum (3.0) and minimum (2.70) number of seeds per pod was recorded in JS 95-60 and the maximum (2.90) and minimum (2.70) number of seeds per pod was recorded in JS 93-05.

Amongst the different yield contributing characters the test weight is important which influences the grain yield directly. The perusal of data reveals that JS 93-05 recorded maximum seed index (12.0 g), closely followed by JS 95-60 (11.8 g) while minimum seed index recorded 10.60 g in JS 93-05 and 11.40 g in JS 95-60 respectively.

Yield of the crop is the result of the various biotic and environmental factors, which are responsible for changes brought about in the productivity. Effectiveness of any treatment could be judged by the magnitude of changes in the productivity brought about by that particular treatment. The seed yield was recorded per net plot and then it was converted into kg/ha. The yield after harvesting was significantly different in both Soybean varieties in both years of investigation in the same trend. Based on 2 years data, JS 93-05 significantly recorded maximum yield (21.08 to 22.90 q/ha) while JS 95-60 attained significantly (19.60 to 20.78 q/ha) respectively during 2016-17. A critical examination of data indicates that both varieties increased the straw yield of soybean. However, the maximum (29.80 q/ha) straw yield in JS 95-60 was recorded in T_8 treatment. JS 93-05 was also found to be at par *i.e.* 29.8 q/ha in T_{12}. The lowest Stover yield (26.30 q/ha) was noted in T_1 treatment.

Studies on *Rabi* season crops

Different Rabi crops were grown in succession to soybean under different crop-sequences, these crops were wheat, chickpea, garden pea for seeds and garlic, onion, Potato for spice and vegetable in different crop sequences. The yield attributing characters and economic yields of these are not directly comparable with each other. Therefore data generated on these aspects were not analyzed statistically.

But data generated on these crops were used to compare the relative performance of different Crop-sequences with the help of suitable scientific indices.

Average data on pods/m in chickpea and vegetable pea, tubers/m in potato were recorded related to crops. Average data pertaining to test weight of wheat, seed index of chickpea, seeds in ear head of wheat/m, seeds in pod of chickpea/m are affected by crop sequences in both years which were numerically comparable in all crop-sequences.

The economic yield means the weight of produce of crop for the purpose for which, it was grown Data on economic yields of different *rabi* crops are given in Table 4.

Chickpea and garden pea crops were grown for seed yields and potato as well as Onion and garlic were grown for tuber and bulb production respectively. In case of garden pea, marketable seed yields were recorded by summation of the weight of pods obtained from different pickings. The haulm yields were also recorded after final picking of marketable green pods. Data pertaining to different economics and straw yield of various crop-sequences are different in their morphological nature. Hence, Statistical analysis of the economic yield obtained from these crops was not made.

Studies on *Zaid* Season Crops

Different *zaid* crops were grown in succession to *rabi* crops under various crop-sequences. These crops were onion and garlic as per different crop- sequences though the yield attributes and economic yields are not comparable directly with each other and some important characters were recorded for assessment of relative performance of various crop-sequences. Different *zaid* crops were grown for different purposes, Onion and garlic were grown for bulb yield and its plant residues were turned down in the soil as green manure after harvesting to record its bulb yield and haulm/stick remained after digging of bulbs were allowed for composting.

System productivity

The total productivity of cropping system was calculated based on total yield of *kharif, rabi* and *zaid* crops converted in to soybean equivalent yield. Data pertaining to Soybean equivalent yield (SEY) as affected by different cropping systems is presented in Table 5. It is conspicuous from the data that different cropping sequences exercised significant effect on Soybean Equivalent Yield. Two varieties of Soybean were grown during *Kharif* in various crop sequences. The market Value of seed yield of both Soybean varieties was almost similar.

Hence, SEY of JS 95-60 and JS 93-05 was determined to compare the relative performance of both Soybean varieties. But crop components were changed during succeeding *Rabi* and *Zaid* seasons in these crop-sequences. The economic yields (seeds. tubers, pods, bulb and cloves etc. as need based produce for the purpose) of these crops are not comparable with each other. Hence, economic yields of these crops were converted into system productivity in terms of soybean equivalent yields (SEY) with the help of existing market values during the year 2015-16 and 2016-17.

During *Kharif* season, the SEY'S of Soybean varieties significantly varied in different crop-sequences during both years of investigation. The SEY's of soybean varieties were in the same trend during both years under different crop-sequences, hence analysis of data were also made.

Table.1 Mean yield attributes (Number of pods/plant, Number of seeds/pod, Seed index) of Soybean varieties at maturity stage under different crop sequences

Crop sequences		Number of pods/plant		Number of seeds/pod		Seed index (weight of 100 seeds in gm)	
		2015-16	2016-17	2015-16	2016-17	2015-16	2016-17
T_1	Soybean (JS 95-60) - Wheat (HI-1544) aestivum	34.2	36.8	2.6	2.8	11.2	11.5
T_2	Soybean (JS 95-60) - Wheat (HI-8663) durum	34.4	36.8	2.7	2.7	11.3	11.4
T_3	Soybean (JS 95-60) - Chickpea (JG-130) desi	34.6	40.1	2.7	2.7	11.5	11.4
T_4	Soybean (JS 95-60) - Chickpea (RVKG-101) Kabuli	35.7	40.2	2.7	2.9	11.6	11.5
T_5	Soybean (JS 95-60) - Garlic (G-282)	36.8	41.3	2.7	3.0	11.7	11.8
T_6	Soybean (JS 95-60) - Onion (AFLR)	34.6	41.3	2.7	2.8	11.2	11.5
T_7	Soybean (JS 95-60) - Potato (Kufri jyoti) - Onion (AFLR)	35.4	42.8	2.7	2.8	11.5	11.6
T_8	Soybean (JS 95-60) - Garden pea (Arkel) - Garlic (G-282)	35.5	43.2	2.7	2.7	11.6	11.7
T_9	Soybean (JS 93-05) - Wheat (HI-1544) aestivum	36.2	39.8	2.7	2.8	11.6	11.7
T_{10}	Soybean (JS 93-05) - Wheat (HI-8663) durum	39.2	38.9	2.8	2.9	12.0	11.8
T_{11}	Soybean (JS 93-05) - Chickpea (JG-130) desi	37.2	39.8	2.8	2.8	11.8	11.9
T_{12}	Soybean (JS 93-05) - Chickpea (RVKG-101) Kabuli	36.6	39.7	2.7	2.8	11.6	11.7
T_{13}	Soybean (JS 93-05) - Garlic (G-282)	39.0	40.3	2.8	2.9	11.9	12.0
T_{14}	Soybean (JS 93-05) - Onion (AFLR)	41.9	44.6	2.6	2.9	11.0	11.5
T_{15}	Soybean (JS 93-05) - Potato (Kufri jyoti) - Onion (AFLR)	47.6	45.8	2.6	2.8	10.7	10.9
T_{16}	Soybean (JS 93-05) - Garden pea (Arkel) - Garlic (G-282)	48.3	47.5	2.7	2.7	10.6	10.8

Table.2 Mean yield attributes (Pods or ear head or tubers/m^2, bulb diameter, no. of scales and average weight of bulbs) of *Rabi* crops under different crop sequences during the year 2015-16 and 2016-17

Crop sequences		Pods or ear heads or tubers/m^2 (#)		Bulb diameter (cm)		No. of cloves/scales per bulb		Average weight of 10 bulbs (g)	
		2015-16	2016-17	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17
T_1	Soybean (JS 95-60) - Wheat (HI-1544) aestivum	236.5	234.2	-	-	-	-	-	-
T_2	Soybean (JS 95-60) - Wheat (HI-8663) durum	235.8	236.2	-	-	-	-	-	-
T_3	Soybean (JS 95-60) - Chickpea (JG-130) desi	1810.0	1881.0	-	-	-	-	-	-
T_4	Soybean (JS 95-60) - Chickpea (RVKG-101) Kabuli	1980.0	2052.0	-	-	-	-	-	-
T_5	Soybean (JS 95-60) - Garlic (G-282)	-	-	4.50	4.60	21.33	23.03	309.0	313.98
T_6	Soybean (JS 95-60) - Onion (AFLR)	-	-	5.50	5.65	11.65	12.10	537.50	548.75
T_7	Soybean (JS 95-60) - Potato (Kufri jyoti) - Onion (AFLR)	297.9	292.5	-	-	-	-	-	-
T_8	Soybean (JS 95-60) - Garden pea (Arkel) - Garlic (G-282)	522.0	498.0	-	-	-	-	-	-
T_9	Soybean (JS 93-05) - Wheat (HI-1544) aestivum	235.8	236.5	-	-	-	-	-	-
T_{10}	Soybean (JS 93-05) - Wheat (HI-8663) durum	234.7	234.8	-	-	-	-	-	-
T_{11}	Soybean (JS 93-05) - Chickpea (JG-130) desi	1870.0	1895.0	-	-	-	-	-	-
T_{12}	Soybean (JS 93-05) - Chickpea (RVKG-101) Kabuli	1986.0	2025.0	-	-	-	-	-	-
T_{13}	Soybean (JS 93-05) - Garlic (G-282)	-	-	4.80	4.90	22.20	23.60	315.5	318.6
T_{14}	Soybean (JS 93-05) - Onion (AFLR)	-	-	5.90	6.40	11.80	12.50	540.6	550.5
T_{15}	Soybean (JS 93-05) - Potato (Kufri jyoti) - Onion (AFLR)	298.2	294.3	-	-	-	-	-	-
T_{16}	Soybean (JS 93-05) - Garden pea (Arkel) - Garlic (G-282)	514.0	505.0	-	-	-	-	-	-

Table.3 Mean yield attributes (average bulb diameter, no. of scales and average weight of bulbs) of *Zaid* crops under different crop sequences during the year 2015-16 and 2016-17

Crop sequences		Bulb diameter (cm)		No. of scales per bulb		Average weight of 10 bulbs (g)	
		2015-16	2016-17	2015-16	2016-17	2015-16	2016-17
T_1	Soybean (JS 95-60) - Wheat (HI-1544) aestivum	-	-	-	-	-	-
T_2	Soybean (JS 95-60) - Wheat (HI-8663) durum	-	-	-	-	-	-
T_3	Soybean (JS 95-60) - Chickpea (JG-130) desi	-	-	-	-	-	-
T_4	Soybean (JS 95-60) - Chickpea (RVKG-101) Kabuli	-	-	-	-	-	-
T_5	Soybean (JS 95-60) - Garlic (G-282)	-	-	-	-	-	-
T_6	Soybean (JS 95-60) - Onion (AFLR)	-	-	-	-	-	-
T_7	Soybean (JS 95-60) - Potato (Kufri jyoti) - Onion (AFLR)	4.48	4.55	11.38	11.95	487.50	476.25
T_8	Soybean (JS 95-60) - Garden pea (Arkel) - Garlic (G-282)	4.23	4.10	19.33	20.03	277.25	276.45
T_9	Soybean (JS 93-05) - Wheat (HI-1544) aestivum	-	-	-	-	-	-
T_{10}	Soybean (JS 93-05) - Wheat (HI-8663) durum	-	-	-	-	-	-
T_{11}	Soybean (JS 93-05) - Chickpea (JG-130) desi	-	-	-	-	-	-
T_{12}	Soybean (JS 93-05) - Chickpea (RVKG-101) Kabuli	-	-	-	-	-	-
T_{13}	Soybean (JS 93-05) - Garlic (G-282)	-	-	-	-	-	-
T_{14}	Soybean (JS 93-05) - Onion (AFLR)	-	-	-	-	-	-
T_{15}	Soybean (JS 93-05) - Potato (Kufri jyoti) - Onion (AFLR)	4.51	4.55	12.50	12.70	488.60	475.90
T_{16}	Soybean (JS 93-05) - Garden pea (Arkel) - Garlic (G-282)	4.60	4.65	20.60	21.50	278.50	279.80

Table.4 Mean Economic yield (q/ha) in different seasons under various crop sequences

Crop sequences		Grain/bulb/tuber yields (q/ha) #						Straw/haulm yield (q/ha) ##					
		Kharif		Rabi		Summer		Kharif		Rabi		Summer	
		2015-16	2016-17	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17
T_1	Soybean (JS 95-60) - Wheat (HI-1544) aestivum	18.41	19.60	45.83	49.30	-	-	25.39	26.3	66.23	65.48	-	-
T_2	Soybean (JS 95-60) - Wheat (HI-8663) durum	18.48	19.87	49.40	53.05	-	-	26.06	26.8	62.45	65.00	-	-
T_3	Soybean (JS 95-60) - Chickpea (JG-130) desi	18.81	20.11	15.80	16.95	-	-	27.28	29.5	23.40	21.93	-	-
T_4	Soybean (JS 95-60) - Chickpea (RVKG-101) Kabuli	19.05	19.03	17.23	18.68	-	-	25.28	28.5	23.30	24.15	-	-
T_5	Soybean (JS 95-60) - Garlic (G-282)	19.37	20.13	83.43	84.75	-	-	26.46	28.4	13.31	13.93	-	-
T_6	Soybean (JS 95-60) - Onion (AFLR)	19.30	20.22	214.00	226.18	-	-	26.52	27.8	12.41	13.19	-	-
T_7	Soybean (JS 95-60) - Potato (Kufri jyoti) - Onion (AFLR)	19.58	20.78	179.68	194.15	185.56	192.60	26.72	27.6	108.75	111.13	12.29	12.65
T_8	Soybean (JS 95-60) - Garden pea (Arkel) - Garlic (G-282)	20.02	20.46	11.60	12.58	68.40	71.75	28.46	29.8	15.04	15.20	12.80	13.20
T_9	Soybean (JS 93-05) - Wheat (HI-1544) aestivum	20.43	21.25	47.88	47.73	-	-	26.22	28.8	67.23	66.80	-	-
T_{10}	Soybean (JS 93-05) - Wheat (HI-8663) durum	20.17	21.08	51.23	51.73	-	-	27.22	27.55	65.20	67.00	-	-
T_{11}	Soybean (JS 93-05) - Chickpea (JG-130) desi	19.69	21.44	16.90	17.30	-	-	27.63	28.8	22.80	22.50	-	-
T_{12}	Soybean (JS 93-05) - Chickpea (RVKG-101) Kabuli	19.41	21.35	18.65	19.71	-	-	21.74	29.8	23.10	25.60	-	-
T_{13}	Soybean (JS 93-05) - Garlic (G-282)	20.04	22.33	85.90	86.8	-	-	21.8	28.6	14.20	14.50	-	-
T_{14}	Soybean (JS 93-05) - Onion (AFLR)	20.31	22.85	217.80	228.5	-	-	23.92	25.9	12.48	14.20	-	-
T_{15}	Soybean (JS 93-05) - Potato (Kufri jyoti) - Onion (AFLR)	19.67	22.90	182.50	198.30	193.48	197.85	23.88	25.9	110.00	112.50	13.60	13.90
T_{16}	Soybean (JS 93-05) - Garden pea (Arkel) - Garlic (G-282)	20.65	22.48	12.30	13.25	70.65	73.60	24.17	26.8	15.60	16.10	13.80	14.00

Grain yields (q/ha)# = Grain yield in soybean, wheat, seed yield in chick pea, tuber in potato, bulb yield in onion and garlic
Straw yield (q/ha)##= Straw yield in soybean, wheat, chick pea and garden pea, haulm yield in onion, garlic and potato.

Table.5 Mean Soybean Equivalent Yield (q/ha) in different seasons under various crop sequences

Crop sequences		*Kharif* Season		*Rabi* Season		*Zaid* Season		SEY (q/ha)	
		2015-16	2016-17	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17
T_1	Soybean (JS 95-60) - Wheat (HI-1544) aestivum	18.41	19.15	29.14	31.03	-	-	47.55	50.63
T_2	Soybean (JS 95-60) - Wheat (HI-8663) durum	18.48	19.70	30.91	33.08	-	-	49.39	52.95
T_3	Soybean (JS 95-60) - Chickpea (JG-130) desi	18.81	20.11	22.65	24.00	-	-	41.46	44.11
T_4	Soybean (JS 95-60) - Chickpea (RVKG-101) Kabuli	19.05	19.03	27.65	29.90	-	-	46.73	48.93
T_5	Soybean (JS 95-60) - Garlic (G-282)	19.37	20.13	61.80	62.77	-	-	81.17	82.90
T_6	Soybean (JS 95-60) - Onion (AFLR)	19.30	20.22	79.26	84.77	-	-	98.55	103.92
T_7	Soybean (JS 95-60) - Potato (Kufri jyoti) - Onion (AFLR)	19.58	20.78	79.86	86.29	68.73	71.33	168.17	178.20
T_8	Soybean (JS 95-60) - Garden pea (Arkel) - Garlic (G-282)	20.02	20.46	17.19	18.63	51.67	53.15	87.88	92.24
T_9	Soybean (JS 93-05) - Wheat (HI-1544) aestivum	20.43	21.25	30.91	33.08	-	-	51.34	54.33
T_{10}	Soybean (JS 93-05) - Wheat (HI-8663) durum	20.17	21.08	31.60	34.80	-	-	52.77	55.88
T_{11}	Soybean (JS 93-05) - Chickpea (JG-130) desi	19.69	21.44	23.50	24.75	-	-	43.19	46.44
T_{12}	Soybean (JS 93-05) - Chickpea (RVKG-101) Kabuli	19.41	21.35	28.50	30.50	-	-	47.91	51.85
T_{13}	Soybean (JS 93-05) - Garlic (G-282)	20.04	22.33	30.56	63.50	-	-	82.54	85.83
T_{14}	Soybean (JS 93-05) - Onion (AFLR)	20.31	22.85	81.50	85.45	-	-	100.81	108.05
T_{15}	Soybean (JS 93-05) - Potato (Kufri jyoti) - Onion (AFLR)	19.67	22.90	80.82	86.29	71.66	73.28	172.15	182.47
T_{16}	Soybean (JS 93-05) - Garden pea (Arkel) - Garlic (G-282)	20.65	22.48	17.20	19.95	52.33	54.52	90.18	96.70
	SEm±	0.515	0.579	2.82	1.50	0.66	0.68	1.41	1.75
	CD (P=0.05)	1.472	1.656	8.07	4.29	1.90	1.95	4.04	5.00

Based on 2-year data, soybean variety JS 93-05 significantly topped in SEY's (19.67 to 22.90 q/ha) in T_{15} among both varieties, which was at par to JS 95-60 (20.02 to 20.46 q/ha) in T_8 treatment.

The SEY's significantly varied due to different crop-component of various crop-sequences during *rabi* season too, in both years in the same manner. Based on 2-year data, the SEY's were significantly maximum (86.29 q/ha) by growing potato followed by onion during rabi season in succession to soybean under T_{15}, among all crops. Growing of onion and garlic in succession to soybean was next to it in respect of SEY (85.45 q/ha) under T_{14} which was also significantly higher than other cropping systems sequenced with others. Crop-sequences with SEY's of 79.86 and 86.29 q/ha, respectively being at par to growing of potato in *rabi* and onion in *zaid* after soybean. Cultivation of onion (T_6 & T_{14}) and garlic (T_5 & T_{13}) after soybean led to record the comparable SEY's of 84.77, 85.45 q/ha and 62.77, 63.50 q/ha, respectively, which were significantly higher than rest of *rabi* crops. Sequential cropping of soybean-garden pea-garlic –T_{10} and T_2 (33.08 q/ha and 33.08 q/ha) were also significantly at par to the treatments i.e. T_7 and $T_{15,}$ respectively after soybean were next in descending order with regard to SEY's, but the variations between T_1, T_2, T_3, T_4 as well as T_9, T_{10}, T_{11} and T_{12} were not significant with each other.

During *zaid* season, in both years i.e. 2015-16 and 2016-17, SEY was significantly maximum (73.28 q/ha) with cultivation of onion under treatment T_{15} closely followed by T_7 (71.33 q/ha) whereas SEY was minimum (51.67 and 53.15 q/ha) with cultivation of garlic under treatment T_{16} and T_8 respectively among all crops. The next best *zaid* crop was onion when transplanted in the month of 1st week of January under T_{15} with SEY of 73.28 q/ha closely followed by Soybean (JS 95-60)-Potato (Kufri jyoti)-Onion under T_7 (71.33 q/ha). Onion crop was superior over garlic *zaid* crop for SEY'S during *zaid* season. Cultivation of onion under T_7 and T_{15} produced SEY's of 68.73 and 71.33 q/ha and 71.66, 73.28 q/ha in T_{15} during 2015-16 and 2016-17, respectively and ranked significantly next to garlic crop.

Data pertaining to SEY's for both years under different cropping systems are presented in Table 5 and data revealed that the maximum (182.47 q/ha) soybean equivalent yield in entire experiment was recorded in T_{15} Soybean (JS 93-05) - Potato (Kufri jyoti) - Onion (AFLR) treatment which was significantly highest than all other treatments, immediately followed by T_7 Soybean (JS 95-60) - Potato (Kufri jyoti) - Onion (AFLR) (178.20 q/ha) treatment. Minimum (44.11 q/ha) soybean equivalent yield was recorded in T_3 treatment. T_{14} Soybean (JS 93-05) - Potato (Kufri jyoti) and T_6 .Soybean (JS 95-60) - Potato (Kufri jyoti) was at par with T_5, T_8, $T_{13,}$ and T_{16} treatments. But it was significantly higher as compared to $T_{1,}$ $T_{3,}$ $T_{4,}$ T_{11} and $T_{12.}$ Thereafter, the remaining treatments *i.e.* T_2, T_5, T_8, T_9 and T_{10} resulted in Soybean Equivalent Yield in the lower range but they were statistically significant over T_2. Similar high values of system productivity with the inclusion of high yielding crops under diversified intensive cropping systems have been also reported by several other workers from the studies made under varying agro-climatic conditions (Sharma *et al.,* 2008; Chitle *et al.,* 2011; Narkhede, *et al.,* 2011; Tyagi *et al.,* 2011; Kumar, *et al.,* 2012; Billore, 2013; Gallani *et al.,* 2013; Shrikant *et al.,* 2013; Meena *et al.,* 2013; Prajapat *et al.,* 2014; Shridhara *et al.,* 2017, Turkhede *et al.,* 2017; Chavan *et al.,* 2018; Jugnahake *et al.,* 2018; Sammauria, *et al.,* 2018; Bhargavi and Behera, 2019). It was observed that the Soybean (JS 93-05) - Potato (Kufri jyoti) - Onion (AFLR) treatment

was superior over all other cropping sequences and recorded the highest soybean equivalent yield of (182.47 q/ha) closely followed by T_7 Soybean (JS 95-60) - Potato (Kufri jyoti) - Onion (AFLR) (178.20 q/ha) which was at par with T_5, T_8, T_{13}, and T_{16} treatments while SEY found lowest (44.11 q/ha) in T_3- Soybean (JS 95-60)-Chickpea (JG-130) treatment.

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