Indian J. Dryland Agric. Res. & Dev. 2022 37(1): 15-19 10.5958/2231-6701.2022.00004.5

Evaluation of Different Soybean Based Rainfed Cropping Sequences in Vertisols of Madhya Pradesh

Narendra Kumawat, M.L. Jadav, D.V. Bhagat, S.K. Choudhary and Deepika Chourey

All India Coordinated Research Project for Dryland Agriculture, College of Agriculture (RVSKVV)
Indore - 452 001, Madhya Pradesh, India

Email: kumawatandy@gmail.com

ABSTRACT: A field experiment was conducted at AICRP for Dryland Agriculture, College of Agriculture (RVSKVV), Indore (MP) during 2018-19 to 2020-21, to find out the suitable cropping sequences for *Malwa* and *Nimar* valley region. Nine cropping sequences including soybean/maize/blackgram-based cropping systems, *viz.,* soybean-chickpea, soybean-safflower, soybean-mustard, maize-chickpea, maize-safflower, maize-mustard, blackgram-chickpea, blackgram-safflower and blackgram-mustard were tested in randomized block design with 5 replications. Among the sequences, soybean equivalent yield of maize - chickpea cropping sequence was the highest (4153/ha), followed by maize-mustard (3293/ha) and maize-safflower sequence (3222 /ha). Existing soybean-chickpea sequence recorded soybean equivalent yield of 2586 kg/ha, which was 60.60% lesser than maize-chickpea cropping sequence. The maize-chickpea cropping sequence recorded the highest gross returns (Rs. 1,86,890/ha), net returns (Rs. 1,46,890/ha) and B:C ratio (4.67) followed by maize-mustard (Rs.1,48,200/ha Rs.1,08,200/ha and 3.71, respectively) and maize-safflower sequence (Rs.1,44,990/ha Rs.1,04,990/ha and 3.62, respectively). Similarly, the maximum production efficiency (18.06 kg/ha/day), economics efficiency (638.65 Rs/ha /day) and relative production efficiency (60.60%) were recorded under maize-chickpea cropping sequence. Highest land use efficiency (98.63%) was noticed with maize-mustard followed by blackgram-mustard sequence.

Key word: Chickpea, crop sequences, economics, LUE, rainfed, SEY, soybean, Vertisols

Introduction

Rainfed cropping is practiced on 1.13 billion ha globally (Biradar *et al*., 2009), and meets about 60 per cent of the food and nutritional needs of the world's population. Rainfed cropping in India is practiced on 72 m ha, mostly in arid, semi-arid and sub-humid climatic zones and constitutes about 51 per cent of the net cultivated area. Low and erratic rainfall, degraded soils, and poor infrastructure are among the principal constraints in the rainfed areas of India. Thus, intensive cropping of Vertisols requires a careful management of soil temperature and moisture regimes (Srinivasarao *et al*., 2012).

Soybean [*Glycine max* (L.) Merill] based cropping systems are important for sustaining agricultural production and maintain in soil fertility with an ecological balance (Khandkar *et al*., 2019). Sustainability aims at balanced use of all available resources to achieve maximum production with minimum exploitation of natural resources (Morya *et al*., 2018 and Tomar *et al*., 2018). Soybean is grown both as an oilseed and grain legume. It fixes atmospheric nitrogen in soil and makes it available to partially fulfill the nitrogen requirement of succeeding crop (Kumawat *et al*., 2021 and Rahangdale *et al*., 2022). The traditional cropping systems in *kharif* are soybean, cotton, maize, etc. and intercropping systems are soybean + maize/pigeonpea, etc. Length of growing period is 90-120 days. Generally, soybean is grown as a rainfal crop under Vertisols and associated soils. It has resulted in increased cropping intensity and profitability (Rahangdale *et al*., 2021). In Malwa and Nimar valley region of MP, 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 Vertisol and associated soils of Central India under the regime is soybean-wheat in which soybean is a rainfed crop. Both soybean and wheat are highly productive crops and predominantly grown in a sequential cropping, particularly under irrigated production system in Vertisol of Madhya Pradesh (Vyas *et al*., 2008).

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. Long-term regular practice of soybean-chickpea and soybean-wheat system in the growing region is posing severe problems to the growers such as difficulty 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. Under such circumstances, the diversification of crops under soybean based cropping system assumes significance for improving the productivity and profitability per unit area per year without jeopardizing the soil health. The resource use efficiency *viz.,* land use efficiency and water productivity and employment opportunities can be increased with diversification of soybean based cropping system with minimization of agricultural risks (Prajapat *et al*., 2015 and Singh and Kushwaha, 2018). Jadav *et al.* (2021) reported that excess rainfall during recent years severely affected the *kharif* crops production, but if provision of rain water harvesting is associated with the cropping sequences, economic loss of *kharif* crops can be compensated by enhancing *rabi* crop productivity. The present study mainly aims at evaluating different soybean based cropping sequences on productivity and profitability under rainfed condition.

Materials and Methods

A field experiment was conducted in randomized block design (RBD) with nine different soybean/maize/blackgram-based cropping systems, viz., soybean-chickpea, soybean-safflower, soybean-mustard, maize-chickpea, maize-safflower, maize-mustard, blackgram-chickpea, blackgram-safflower and blackgram-mustard. Soybean/maize/blackgram were sown *kharif* (15th June to 15th September) and chickpea/safflower/mustard were sown *rabi* (1st October to 31st March) at the AICRP for Dryland Agriculture, College of Agriculture (RVSKVV), Indore, Madhya Pradesh, India. This station is situated in the central highlands (Malwa) Gujarat plain Kathiawar peninsular semi-arid eco-region at 76°54' E longitude and 22°43' N latitudes at an altitude of 567 m above MSL. The climate of the area is hot dry semi-arid with an average annual rainfall ranging from 825-1100 mm. The length of growing period is 90-120 days.

The total annual rainfall was 756.8, 1567.7 and 1075.2 mm during 2018-19, 2019-20 and 2020-21, respectively. The experimental soils of the area are medium, deep and shallow black soils with low organic carbon content (0.41%), low available N (152 kg/ha), medium available P_2O_5 (13.5 kg/ha) and high available K_2O (422 kg/ha). All the crops in the cropping sequence were grown in a gross plot area of 1080 sqm, with recommended package and practices. Table 1 provides details of crop-variety and inputs used.

Recommended doses of fertilizers to each crop in various cropping systems were applied (Table 1). At maturity all crops were harvested manually from a net plot area. After harvesting, data pertaining to by produce and economic yield of each crop were converted into per hectare. Economic produce of all the crops was obtained manually. To compare the performance of different cropping sequences, economic yield of all the crops was converted into soybean equivalent yield (SEY) based on the prevailing market price. To study resource use efficiency of the system, land use efficiency (LUE) was calculated from total duration of the crop in cropping system divided by 365 and production efficiency (PE; kg/ha /day) was calculated by dividing total economic yield (SEY) by total duration of crops in the cropping system. The relative production efficiency (RPE) of the system was calculated and expressed as percentage.

$$\text{RPE} = (B - A)/A \times 100$$

where, A is the productivity (SEY) of soybean-soybean system and B is the productivity (SEY) of the diversified cropping system.

Production efficiency (PE) was expressed as the ratio of system productivity in kg SEY/ha to total duration of the system in days. Production efficiency in economic terms was calculated by taking system net returns instead of SEY (Kumawat *et al*., 2012). Statistical analysis of the data was carried out using standard analysis of variance (Gomez and Gomez, 1984).

Result and Discussion

Productivity of *kharif* crops

The three crop sequences *i.e.* soybean-chickpea/mustard/safflower, maize-chickpea/mustard/ safflower and blackgram-chickpea/mustard/safflower were grown under rainfed condition during *kharif* and *rabi* season (Table 2). Among the soybean based sequences, mean data of three years showed that the maximum plant height (53.61 cm), branches/plant (3.33) pods/plant (35.21), seed index (12.54 g) and yield of soybean crop

Table 1: Agronomic management adopted for crops grown during the experiment

Cropping sequence	Variety		Seed rate (kg/ha)		Spacing (cm x cm)		Fertilizers (kg/ha); N:P_2O_5:K_2O	
	Kharif	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*
T_1-Soybean-chickpea	JS 20-34	RVG-203	80	80	45 x 10	45 x 10	20:60:40	20:60:40
T_2-Soybean-safflower	JS 20-34	JSI 97	80	20	45 x 10	45 x 15	20:60:40	20:60:40
T_3-Soybean-mustard	JS 20-34	Varuna	80	6	45 x 10	45 x 15	20:60:40	50:25:25
T_4-Maize-chickpea	NK 7720	RVG-203	20	80	45 x 20	45 x 10	120:60:40	20:60:40
T_5-Maize-safflower	NK 7720	JSI 97	20	20	45 x 20	45 x 15	120:60:40	20:60:40
T_6-Maize-mustard	NK 7720	Varuna	20	6	45 x 20	45 x 15	120:60:40	50:25:25
T_7-Blackgram-chickpea	JU 86	RVG-203	20	80	45 x 10	45 x 10	20:60:40	20:60:40
T_8-Blackgram -safflower	JU 86	JSI 97	20	20	45 x 10	45 x 15	20:60:40	20:60:40
T_9-Blackgram -mustard	JU 86	Varuna	20	6	45 x 10	45 x 15	20:60:40	50:25:25

Table 2: Growth, yield parameters and yield of *kharif* crops and yield of *rabi* crops as affected by cropping sequences (Mean data of 3 years)

Cropping sequence	Plant height (cm)	Pods/cobs plant	Branches/tillers plant	Yield of *kharif* crops (kg/ha)	Yield of *rabi* crops (kg/ha)
T_1-Soybean-chickpea	53.61	35.21	3.33	896	1521
T_2-Soybean-safflower	53.52	34.85	3.14	850	680
T_3-Soybean-mustard	52.93	34.55	3.13	888	671
T_4-Maize-chickpea	186.34	1.22	-	2552	1441
T_5-Maize-safflower	185.62	1.15	-	2502	648
T_6-Maize-mustard	184.26	1.15	-	2496	598
T_7-Blackgram-chickpea	51.62	22.53	4.02	695	1457
T_8-Blackgram-safflower	51.32	22.44	3.92	680	721
T_9-Blackgram-mustard	50.52	21.69	3.81	675	577

(896 kg/ha) were recorded under soybean- chickpea cropping sequence followed by soybean-safflower and soybean-mustard cropping sequence. Similarly, among the maize based sequences, the highest plant height (186.34 cm), cobs/plant (1.22), seed index (115.41 g) and grain yield of maize crop (2552 kg/ha) were noted in maize-chickpea sequence followed by maize-safflower, while the lowest were observed with maize-mustard sequence. Maximum plant height (51.62 cm), branches/plant (4.02), pods/plant (22.53), seed index (8.96 g) and seed yield of blackgram (695 kg/ha) were observed under blackgram-chickpea sequence followed by blackgram-safflower and blackgram-mustard sequence. Similar results were also reported by Shrikant *et al*. (2013), Prajapat *et al*. (2014) and Singh *et al*. (2018).

Productivity of *rabi* crops

Among the soybean cropping sequences, the highest seed yield of *rabi* crop (chickpea) was recorded in soybean-chickpea sequence followed by soybean- safflower, while the lowest seed yield was recorded in soybean-mustard sequences (Table 2). In maize based sequences, the highest yield of *rabi* crop (chickpea) was obtained in maize-chickpea sequence followed by maize-safflower and lowest in maize-mustard sequence. Similarly, with the blackgram based sequence, the maximum seed yield of *rabi* crop (chickpea) was noticed with blackgram-chickpea sequence followed by blackgram-safflower sequence. The lowest seed yield of *rabi* crop (mustard) was recorded under blackgram-mustard sequence.

System equivalent yield and system profitability

System productivity in terms of soybean equivalent yield (SEY) indicated, higher SEY in maize-chickpea followed by maize-safflower and maize-mustard sequence (Table 3). Whereas the lowest SEY was recorded in blackgram based cropping sequences. It is conspicuous from the data that different cropping sequences exercised significant effect on soybean equivalent yield (Singh and Kushwaha, 2018 and Gathiye and Kushwaha, 2019).

Among the different cropping sequences, mean data of 3 years shows that maximum gross return of system, net returns and B:C

Table 3: Soybean equivalent yield (SEY), economics and various efficiencies as affected by cropping sequences (Mean data of 3 years)

Cropping sequence	SEY (kg/ha)	Gross returns of system (Rs./ha)	Net returns of system (Rs./ha)	B:C ratio	Total duration (days)	Production efficiency (kg/ha /day)	Economics efficiency (Rs./ha/day)	Land use efficiency (%)	Relative production efficiency (%)
T_1-Soybean- chickpea	2586	116370	76370	2.91	230	11.24	332.04	63.01	-
T_2-Soybean- safflower	1606	72250	32250	1.81	273	5.88	118.13	74.79	-37.91
T_3-Soybean- mustard	1783	80220	40220	2.01	259	6.88	155.29	70.96	-31.06
T_4-Maize-chickpea	4153	186890	146890	4.67	230	18.06	638.65	63.01	60.60
T_5-Maize- safflower	3222	144990	104990	3.62	273	11.80	384.58	74.79	24.59
T_6-Maize- mustard	3293	148200	108200	3.71	372	9.15	300.56	98.63	27.35
T_7-Blackgram-chickpea	2314	104125	64125	2.60	205	11.29	312.80	56.16	-10.52
T_8-Blackgram -safflower	1481	66650	26650	1.67	248	5.97	107.46	67.95	-42.73
T_9-Blackgram - mustard	1444	64995	24995	1.62	347	4.16	72.03	95.07	-44.15
SEm±	58	2326	1678	0.07	-	-	-	-	-
LSD (P=0.05)	168	6701	4833	0.20	-	-	-	-	-

ratio were obtained with maize-chickpea sequence followed by maize-safflower and maize-mustard sequence. The next best cropping sequences with regard to gross returns of system, net returns and B:C ratio was soybean-chickpea and blackgram-chickpea. The lowest gross returns, net returns and B:C ratio were obtained in blackgram-mustard and soybean-safflower cropping sequence. This might be due to higher yield of maize and chickpea under maize-chickpea cropping sequence leading to increased returns over other cropping sequences. Higher system profitability may be attributed to higher productivity of maize than other *kharif* crops and lower duration of the crops in sequence. Similar findings were also reported by Prajapat *et al*. (2015) and Singh *et al*. (2019).

Production, economic and land use efficiency

The highest production efficiency and economic efficiency were obtained under maize-chickpea sequence followed by maize-safflower sequence (Table 3). The next best cropping sequences were blackgram-chickpea and soybean-chickpea. This might be due to higher soybean equivalent yield in this cropping sequence (Prajapati *et al*., 2015). The lowest production and economic efficiency were noticed in blackgram-mustard and soybean-safflower cropping sequence. The highest land use efficiency of systems was recorded under maize-mustard and blackgram-mustard cropping sequence (Table 3). These two systems occupied land for almost similar duration, thereby achieved similar LUE. While blackgram-chickpea and maize/soybean-chickpea recorded lower LUE. Similarly, among the various sequences, the maximum relative production efficiency was noted under maize-chickpea followed by maize-mustard and maize-safflower sequences. Similar results are also reported by Kumpawat (2001), Karunakaran and Behera (2015) and Kumar *et al*. (2022).

Conclusion

Based on three years of experimentation, it can be concluded that the maize-chickpea cropping sequence can be recommended for diversifying soybean-chickpea system to increase the productivity and profitability of farmers in rainfed areas of Malwa-Nimar valley of Madhya Pradesh.

References

Biradar CM, Thenkabail PS, Noojipady P, Li Y, Venkateswarlu D, Turral H, Velpuri M, Gumma MK, Gangalakunta ORP, Cai XL, Schull MA, Alankara RD, Gunasinghe S and Mohideen S. 2009. A global map of rainfed cropland areas at the end of last millennium using remote sensing. *International Journal of Applied Earth Observation and Geoinformation*, 11: 114-129.

Gathiye G and Kushwaha H S. 2019. Productivity of diversified soybean [*Glycine max* (L.) Merrill] based cropping systems in Malwa plateau of Madhya Pradesh, India. *International Journal of Current Microbiology and Applied Sciences*, 8(10): 864-876.

Gathiye G and Kushwaha HS. 2019b. Effect of soybean [*Glycine max* (L.) Merrill] based cropping systems on biomass production in Vertisols of Madhya Pradesh. *Journal of Pharmacognosy and Phytochemistry*, 8(5): 1798-1801.

Gomez KA and Gomez AA. 1984. Statistical Procedures for Agricultural Research. John Willley & Sons, New York.

Jadav ML, Bhagat DV, Girothia OP, Choudhary SK and Kumawat N. 2021. Rainwater harvesting to mitigate climate change effects on the cropping sequences in Malwa region of Madhya Pradesh. *The Pharma Innovation Journal*, 10(7): 461-465.

Karunakaran V and Behera UK. 2015. Tillage and residue management practices on yield, profitability, energy and water use efficiency in soybean-wheat cropping system. *Experimental Agriculture*, doi:10.5958/2231-6701.2022.00004.5.

Khandkar UR, Tiwari SC, Kumawat N, Awani KA, Bangar KS and Singh SP. 2019. Response of micronutrients, organics and biofertilizers on growth and yield of soybean under Vertisols. *Journal of Experimental Zoology*, 20(10): 108-111.

Kumar R, Kumawat N, Mishra JS, Ghosh D, Ghosh S, Choudhary AK and Kumar U. 2022. Weed dynamics and crops productivity as influenced by diverse cropping systems in eastern India. *Indian Journal of Weed Science*, 54(1): 18-24.

Kumawat N, Singh RP, Kumar R, Kumari A and Kumar P. 2012. Response of intercropping and integrated nutrition on production potential and profitability on rainfed pigeonpea. *Journal of Agricultural Science*, 4(7): 154-162.

Kumawat N, Tiwari SC, Bangar KS, Khandkar UR, Awani K Ashok and Yadav RK. 2021. Influence of different sources of plant nutrients on soil fertility, nutrient uptake and productivity of soybean under Vertisols. *Legume Research*, 44(5): 556-561, DOI: 10.18805/LR-4164

Kumpawat BS. 2001. Production potential and economics of different crop sequences. *Indian Journal of Agronomy*, 46(3): 421-424.

Morya J, Tripathi RK, Kumawat N, Singh M, Yadav RK, Tomar IS and Sahu YK. 2018. Influence of organic and inorganic fertilizers on growth, yields and nutrient uptake of soybean (*Glycine max* Merril L.) under Jhabua Hills. *International Journal of Current Microbiology and Applied Sciences*, 7(2): 725-730.

Prajapat K, Vyas AK and Dhar S. 2014. Productivity, profitability and land-use efficiency of soybean (*Glycine max*)-based cropping systems under different nutrient-management practices. *Indian Journal of Agronomy*, 59(2): 229-234.

Prajapat K, Vyas AK and Dhar S. 2015. Effect of cropping systems and nutrient management practices on growth, productivity, economics and nutrient uptake of soybean (*Glycine max*). *Indian Journal of Agricultural Sciences*, 85(9): 1138-1143.

Rahangdale N, Kumawat N, Jadav ML, Bhagat DV, Singh M and Yadav RK. 2022. Symbiotic efficiency, productivity and profitability of soybean as influenced by liquid bio-inoculants and straw mulch. *International Journal of Bio-resource and Stress Management*, 13(1): 9-16.

Rahangdale N, Kumawat N, Jadav ML, Singh M and Bhagat DV. 2021. Effect of liquid bioinoculants and straw mulch on health of Vertisols and productivity of soybean (*Glycine max*). *Crop Research*, 56(3&4): 111-117.

Shrikant C, Tiwari A, Bhoi S, Savu RM, Tomar HS and Urkurkar JS. 2013. Performance of soybean (*Glycine max*)-based cropping sequences under organic, inorganic and integrated nutrient supply systems in a Vertisols. *Indian Journal of Agronomy*, 58(2): 163-167.

Singh AB, Saha JK and Ghosh PK. 2018. Effect of nutrient management practices on soybean (*Glycine max*)-chickpea (*Cicer arietinum*) cropping system for improving seed yield, quality and soil biological health under rainfed condition. *Indian Journal of Agricultural Sciences*, 78: 485-489.

Singh AK and Kushwaha HS. 2018. Assessment of soybean (*Glycine max* Merill L.) based cropping systems through organic and inorganic inputs in Bundelkhand Region. *Journal of Krishi Vigyan*, 6(2): 7-12.

Singh DK, Singh R, Singh GD, Singh AP, Chaturdevi S, Singh JP, Rathi A and Singh M. 2019. Diversification of rice (*Oryza sativa*)-wheat (*Triticum aestivum*) system and its influence on productivity, profitability and energetics under on-farm situation. *Indian Journal of Agronomy*, 62(3): 255-259.

Srinivasarao C, Deshpande AN, Venkateswarlu B, Lal R, Singh AK, Kundu S, Vittal KPR, Mishra PK, Prasad JVNS, Mandal UK and Sharma KL. 2012. Grain yield and carbon sequestration potential of post monsoon sorghum cultivation in Vertisols in the semi arid tropics of central India. *Geoderma*, doi: 175-176,90-93.

Tomar IS, Yadav RK, Tripathi RK, Singh M, Kumawat N and Morya J. 2018. Effect of nutrient management on soybean production. *Journal of AgriSearch*, 5(2): 96-99.

Vyas AK, Billore SD, Chauhan GS and Pandya N. 2008. Agroeconomic analysis of soybean-based cropping systems. *Indian Journal of Fertilizer*, 4(5): 45-51.