

Production potential and Economics of Different Cropping Systems at Farmer's Field in Tikamgarh District of Madhya Pradesh

A. Tyagi

PG Scholar (Agronomy), ITM University, Gwalior (M.P.)

Corresponding authors email: adityatyagips@gmail.com

Abstract

Field trials were conducted at farmer's field in Tikamgarh district of Madhya Pradesh during 2022-23 and 2023-24 to reveal the impact of various crop management practices on production potential and economics of different cropping systems at farmer's field. Among different NPK levels, application of recommended doses of NPK (T_5) exhibited their superiority in terms of higher grain yield of both soybean and wheat crops, higher mean wheat equivalent yield (WEY), higher NMR and B:C ratio over rest of the treatments during both years of study. The recommended doses of NPK (T_5) increased the soybean yield over control (T_1) by 71.2 % and 48.6 % in 2022-23 and 2023-24, respectively and wheat by 35.2 % and 33.9 % in 2022-23 and 2023-24, respectively.

Among different cropping systems, total productivity (45.0 q ha^{-1}), wheat equivalent yield (54.1 q ha^{-1}), per day productivity ($19.3 \text{ kg ha}^{-1} \text{ d}^{-1}$) and net return (Rs. 36882 ha^{-1}) were recorded the highest in soybean-wheat system. Soybean-wheat system resulted into an advantage of net return of Rs. 10467, Rs. 8007 and Rs. 1310 ha^{-1} over sesame-wheat, blackgram-mustard and blackgram-coriander systems, respectively. However, net return per rupee invested (B:C) was recorded highest in blackgram-coriander (1.92). Among different agronomic management practices, application of full RDF through chemical fertilizers + chemical weed control (T_3) increased the yield of soybean and wheat by 36.2 % and 21.0 %, respectively over farmer's practice (T_1). Per day productivity and mean wheat equivalent yield of the soybean-wheat system was also higher under T_3 treatment. Mean data also revealed that application of full RDF through chemical fertilizers + chemical weed control (T_3) gave 39.3% and 14.8% higher net return over T_1 and T_2 treatments, respectively. Similarly, mean B: C ratio was also higher (1.49) when crops were fertilized with full RDF through chemical fertilizers + chemical weed control (T_3) followed by T_2 (1.34) and the lowest (1.19) was recorded under farmer's practices.

Key words: Cropping system, net return, production potential, soybean, WEY

Introduction

Madhya Pradesh has very strong research network and voluminous amount of appropriate technologies have been evolved to boost the production of soybean-wheat cropping system, but even than the average productivity of this cropping system at farmer's field is very low as compared to the potential yield. The reason may be that the most of the technologies have not yet reached to the farmer's field. The low productivity of soybean - wheat cropping system in this region has also been ascribed to several other constraints such as poor field preparation, no seed treatment before sowing, faulty sowing method

(broadcasting), poor plant protection, poor weed management, poor fertilizer management, etc. Among these, low fertilizer use is one of the important factor for low productivity of this cropping system in Tikamgarh district, Madhya Pradesh. It has been observed that farmers have either do not applied or have partially applied the recommended doses of fertilizers because farmers vary in socio-economic parameters, farming skills and managerial ability, etc. The favourable effect of recommended dose of NPK on yield might be ascribed to the availability of sufficient amount of nitrogen as well as other nutrients throughout growth period

which might have increased photosynthetic activity resulting in more vigour plant and ultimately higher grain yield^[4]. Due to high yield potential, these crops require high quantity of nutrients from the soil. Therefore, it necessary to maintain soil fertility for sustainable production of soybean-wheat sequence under rainfed and irrigated conditions. Therefore, conjunctive use of FYM and chemical fertilizers may help in improving physio-chemical properties of soil^[1,2].

A suitable cropping system is also essential for good land use planning and increased productivity per unit area and per unit time. The choice of crops in cropping system depends upon the agro-climatic features of the area, cost and level of various management inputs, availability of water, needs of farmers and soil type, etc. The production potential and economics vary with cropping systems and availability of resources^[3]. The net return per unit area and per unit time can be further increased in this region by adopting other feasible and profitable cropping

Materials and Methods

Three field trials were conducted during two consecutive years of 2022-23 and 2023-24 at Farmer's Field in 3 blocks viz., Tikamgarh, Jatara and Baldeogarh of Tikamgarh district of Madhya Pradesh. In each block, five villages were selected and in each village, three different farmers were selected for trials. In this way, each experiment was conducted at 15 locations i.e., 45 trials were conducted in *kharif* and 45 trials were conducted in *rabi* season. Each block was considered as one replication and yield data was analyzed as per randomized block design.

The treatments of first field trial was comprising 5 different doses of NPK (kg/ha) to soybean and wheat viz., control: 00-00-00 and 00-00-00 (T₁), 20-00-00 and 120-00-00 (T₂), 20-80-00 and 120-60-00

systems. Mustard, coriander and sesame (Til) are also immensely suitable for cultivation in this area. Comparing the suitability of the alternative crops and raising them in appropriate sequences can lead to the development of such cropping systems which provides the farmers maximum production and net return as well as reasonable high input use efficiency.

Therefore, keeping these all in views, three trials were conducted at farmer's field in 3 blocks viz., Tikamgarh, Jatara and Baldeogarh of Tikamgarh district during 2022-23 and -2023-24 with the following three objectives: to demonstrate the influence of different levels of NPK on production potential and economics of soybean-wheat cropping system, to assess the production potential and economics of different cropping systems, and to demonstrate the impact of different nutrient management practices on production potential and economics of soybean-wheat cropping system at farmer's field.

(T₃), 20-00-20 and 120-00-40 (T₄) and recommended: 20-80-20 and 120-60-40 (T₅), respectively. The second field trial comprised 4 different double cropping sequences viz., T₁: soybean-wheat, T₂: blackgram-mustard, T₃: sesame (Til)-wheat and T₄: blackgram-coriander. The third field trial comprised 3 different nutrient management practices to soybean-wheat system viz., Control: Farmer's practice (T₁), 50% recommended dose of fertilizers (RDF) through chemicals + 50% through FYM + chemical weed control (T₂) and full recommended dose of fertilizers (RDF) through chemical + chemical weed control (T₃). For weed control under treatments T₂ and T₃ in third trial, Pursuit (Imazethapyr) and Isoproturon were applied in soybean (15-

20 DAS) and wheat (25-30 DAS), respectively at prescribed doses and volume of spray with knapsack sprayer fitted with flat fan nozzles. The average duration of the soybean-wheat cropping system in third trial was 233 days.

All *kharif* crops were sown with the onset of monsoon as rainfed crops and *rabi* crops were sown with pre-sowing irrigations for better germination and optimum plant population of the crops. After germination, all *rabi* crops were given irrigations as per recommendations. Fertilizers were applied as per recommendation to respective crops. The varieties of crops soybean, black gram, sesame, coriander, mustard and wheat were JS-9305, PU 35, JS 8, JD-1, Rohini and GW 273, respectively. All other agronomic operations and plant protection

Results and Discussion

First trial

The study was undertaken to demonstrate the influence of different levels of NPK on production potential and economics of soybean-wheat cropping system at farmer’s field during 2022-23

measures were followed as per recommendations.

Yield data were transformed into economic data by taking into account the prevailing market price during the study period of the crops. To compare productivity of different cropping systems, wheat grain yield equivalents (WEY, q ha⁻¹) was computed by converting the grain yield of other crops into wheat grain yield on the basis of selling prices during the respective years. The net return (Rs. ha⁻¹) and benefit cost ratio (B:C) were calculated on mean basis to judge the best treatment of NPK for soybean-wheat system, the best cropping sequence and the best nutrient management practices to be adopted by farmers for sustainable crop production.

and 2023-24. The perusal of data presented in Table 2 and 3 reveal that grain yield, NR, B:C ratio of soybean-wheat cropping system was higher during 2023-24 as compared to 2022-23.

Table 1 Effect of different NPK levels on grain yield in soybean-wheat cropping system

Treatments	Grain yield (q/ha)						Mean WEY (q/ha)
	2022-23		2023-24		Mean		
	Soybean	wheat	Soybean	wheat	Soybean	wheat	
T1	7.36	22.7	11.1	29.3	9.23	26.0	40.5
T2	8.31	26.1	12.6	31.8	10.5	29.0	45.4
T3	10.3	29.1	14.8	35.7	12.6	32.4	52.1
T4	9.18	27.6	13.6	33.7	11.4	30.7	48.5
T5	12.6	30.7	16.5	39.2	14.6	35.0	57.9
S. Em ±	0.17	0.47	0.23	0.36	0.20	0.42	-
CD (P=0.05)	0.52	1.39	0.70	1.01	0.61	1.20	-

The response of different NPK treatments to grain yield of soybean-wheat system was similar during both the years

(Table 1). The recommended doses of NPK (T₅) significantly increased the soybean yield over control (T₁) by 71.2 %

and 48.6 % in 2022-23 and 2023-24, respectively and wheat by 35.2 % and 33.9 % in 2022-23 and 2023-24, respectively. Similarly, the recommended dose of nitrogen @ 20 and 120 kg/ha (T₂) to

soybean and wheat, respectively increased the grain yield of soybean by 12.9 % and 13.5 % in 2022-23 and 2023-24, respectively and wheat by 15.0% and 8.5% in 2022-23 and 2023-24, respectively.

Table 2 Net return, additional NR and B:C ratio in soybean-wheat cropping system

Treatments	NMR (Rs. ha ⁻¹)					B:C
	2022-23	2023-24	Mean	Additional cost of cultivation over control (T ₁)	Additional mean NR	
T1	19960	33360	26660	-	-	1.16
T2	24415	37835	31125	1525	4465	1.27
T3	29380	43852	36611	4390	9951	1.34
T4	27490	41651	34571	1990	7911	1.38
T5	35475	50978	43227	4854	16567	1.55

The grain yield of both crops also significantly increased when recommended dose of phosphorous was applied @ 80 and 60 kg/ha with nitrogen (T₃) to soybean by 39.9% and 33.3%; and to wheat by 28.2% and 21.8% in 2022-23 and 2023-24, respectively. Similarly, the application of recommended dose of potassium @ 20 and 40 kg/ha with nitrogen (T₄) increased the grain yield of soybean by 24.7% and 22.55 and of wheat by 21.6% and 15.0% in 2022-23 and 2023-24, respectively, but not upto the yield level of T₃ treatment (nitrogen and phosphorous applied together). These result reflected that soils are more responsive to phosphorous than potassium. The application of recommended doses of NPK was competent to accommodate more healthy plants which finally resulted into higher grain yield. Similar results of well fertilized crops. The mean wheat equivalent yield (WEY) was the highest (57.9 q ha⁻¹) with the application of recommended doses of fertilizers (T₅) in

both soybean and wheat crops followed by T₃ (52.1 q ha⁻¹), T₄ (48.5 q ha⁻¹), T₂ (45.4 q ha⁻¹) and the lowest was in T₁ (40.5 q ha⁻¹).

In general, the net return (NR, Rs. ha⁻¹) was higher in 2023-24 than 2022-23 probably due to higher grain yield of both crops in 2023-24 owing to better rainfall amount and its well distribution. The NR in 2022-23 ranged Rs. 19960 to Rs. 35475 among different treatments while these values were Rs. 33360 to Rs. 50978 in 2023-24. The highest NR of Rs. 35475 and Rs. 50978 during 2022-23 and 2023-24 was recorded with application of recommended doses of NPK (T₅) and the lowest NR of Rs. 19960 and Rs. 33360 with no fertilizer application (T₁) treatment (Table 2).

The mean NR per rupee invested (B:C) was ranged 1.16 to 1.55 among different treatments (Table 2). The mean NMR per rupee invested (B: C) was higher (1.55) when crops were fertilized with recommended doses of NPK (T₅) and the

lowest (1.16) was recorded when no fertilizers were applied to both crops (T₁). It is apparent from the additional net return that nominal increase in additional cost we can get higher additional net monetary returns (Table 2). As in case of treatment T5 (recommended doses of NPK), additional investment of Rs. 4854 ha⁻¹

Second trial

The trial was conducted to assess the production potential and economics of different cropping systems at farmer’s field during 2022-23 and 2023-24. Data in Table 3 reveals that yields of all crops except sesame in different cropping

recorded the additional NMR of Rs. 16567 ha⁻¹ over control. Similarly, additional investment of Rs. 1525 ha⁻¹, Rs. 4390 ha⁻¹ and Rs. 1990 ha⁻¹ in T₂, T₃ and T₄ exhibited an additional NMR of Rs.4465 ha⁻¹, Rs. 9951 ha⁻¹ and Rs. 7911 ha⁻¹ over control (T₁).

sequences were higher during 2023-24 than 2022-23.. Excess vegetative growth of sesame due to high rainfall during 2023-24 resulted into poor fruit setting and reflected into low yield.

Table 3 Seed yield and wheat equivalent yield (WEY) of different cropping systems

Treatments	Grain yield (q ha ⁻¹)							Mean WEY (q ha ⁻¹)
	2022-23		2023-24		Mean			
	Soybean	Wheat	Soybean	Wheat	Soybean	Wheat	Total	
T1: soybean-wheat	12.6	27.9	14.5	34.9	13.6	31.4	45.0	54.1
T2: Blackgram-mustard	4.58	15.5	5.27	15.3	4.93	15.4	20.3	39.2
T3: Sesame-wheat	4.50	28.2	4.04	35.1	4.27	31.7	36.0	42.7
T4: Blackgram-coriander	4.55	9.55	5.17	11.4	4.86	10.5	15.4	45.1
S.Em ±	0.11	0.81	0.54	0.97	0.33	0.89	-	-
CD (P=0.05)	0.35	2.49	1.67	2.95	1.01	2.72	-	-

Among the *kharif* crops, soybean recorded significantly higher grain yield as compared to other crops during both the years of study. Similarly, among *rabi* crops, wheat exhibited significantly higher grain yield followed by mustard and coriander (Table 3). The pooled data revealed that among different cropping systems, the highest total productivity was recorded from soybean-wheat (45.0 q ha⁻¹) followed by sesame-wheat (36.0 q ha⁻¹), blackgram-mustard (20.3 q ha⁻¹) and the lowest was from blackgram-coriander

(15.4 q ha⁻¹) system. Other workers also reported the highest total productivity of soybean-wheat system at Tikamgarh district [6]. Similarly, total productivity in terms of wheat equivalent yield, soybean-wheat also recorded the maximum WEY (54.1 q ha⁻¹) followed by blackgram-coriander (45.1 q ha⁻¹), sesame-wheat (42.7 q ha⁻¹) and was the minimum in blackgram-mustard (39.2 q ha⁻¹). The higher wheat equivalent yield of soybean-wheat system was owing to the fact that these crops have high yield potential than

other crops in different cropping systems. Per day productivity of the system was also observed the highest in soybean-wheat (19.3 kg ha⁻¹ d⁻¹) and the lowest in blackgram-coriander (6.91 kg ha⁻¹ d⁻¹) system.

The net return (Rs. ha⁻¹) of different cropping systems was higher in 2023-24 than 2022-23 probably due to higher grain yield of crops in 2023-24. The higher grain yield of crops in 2023-24 was

due to better rainfall amount and its well distribution resulted into vigour plant growth. The highest net return of Rs. 32035 ha⁻¹, Rs. 41728 ha⁻¹ and Rs. 36882 ha⁻¹ was recorded from soybean-wheat system and the lowest net return of Rs. 22965 ha⁻¹, Rs. 29864 ha⁻¹ and 26415 ha⁻¹ from sesame-wheat system during 2022-23, 2023-24 and from pooled results, respectively (Table 4).

Table 4 Productivity, net return and benefit cost ratio (B:C) from different cropping systems

Treatments	Total duration of system (days)	Productivity of system (kg. ha ⁻¹ d ⁻¹)	Net return (Rs. ha ⁻¹)			Net return (Rs. ha ⁻¹)	Benefit cost ratio (B:C)	Increase in net return over (Rs./ha)		
			2022-23	2023-24	Mean			Black gram - mustard	Sesame - wheat	Black gram - coriander
T1: soybean-wheat	233	19.3	32035	41728	36882	158	1.32	8007	10467	1310
T2: Blackgram-mustard	220	9.23	24561	33189	28875	131	1.60	-	2460	-
T3: Sesame-wheat	231	15.6	22965	29864	26415	114	1.07	-	-	-
T4: Blackgram-coriander	223	6.91	31094	40049	35572	160	1.92	6697	9157	-

Higher net return from soybean-wheat system among different cropping systems was also reported by other works in 1994 at Pantnagar, Uttranchal [5]. However, net return per day was recorded the highest in blackgram-coriander (Rs. 160 ha⁻¹ d⁻¹) system closely followed by soybean-wheat (Rs. 158 ha⁻¹ d⁻¹), blackgram-mustard (Rs. 131 ha⁻¹ d⁻¹) and was the lowest in sesame-wheat (Rs. 114 ha⁻¹ d⁻¹) system. Soybean-wheat system gave an advantage of net return of Rs.

Third trial

The trial was conducted to demonstrate the impact of different nutrient management practices on production potential and economics of soybean-wheat cropping system at

10467 ha⁻¹ over sesame-wheat, Rs. 8007 ha⁻¹ over blackgram-mustard and Rs. 1310 ha⁻¹ over blackgram-coriander system. Similarly, increase in net return from blackgram-coriander over sesame-wheat was Rs. 9157 ha⁻¹ and over blackgram-mustard was Rs. 6697 ha⁻¹. Mean net return per rupee invested (B: C) was also recorded highest in blackgram-coriander (1.92) and was the lowest in sesame-wheat (1.07) system.

farmer’s field during 2022-23 and 2023-24. The trends of data during both the years were similar, therefore, pooled data is described here.

Table 5 Effect of different nutrient management practices on grain yield in soybean-wheat cropping system

Treatments	Grain yield (q ha ⁻¹)		Productivity (kg. ha ⁻¹ d ⁻¹)	Mean WEY (q ha ⁻¹)	Net return (Rs. ha ⁻¹)			Per day net return (Rs. ha ⁻¹)	Benefit cost ratio (B:C)	Increase in net return over Farmers practices (%)
	Soybean	wheat			2022-23	2023-24	Mean			
T1: Farmers practices	10.5	28.1	19.6	45.6	23957	35540	29749	128	1.19	-
T2: 50% RDF through chemical + 50% through FYM + chemical weed control	12.4	32.0	22.6	52.6	30575	41653	36114	155	1.34	21.4
T3: Full RDF through chemical fertilizers + chemical weed control	14.3	34.0	24.8	57.8	35315	47578	41447	178	1.49	39.3
S.Em ±	0.21	0.47	-	-	-	-	-	-	-	-
CD (P=0.05)	0.66	1.47	-	-	-	-	-	-	-	-

The grain yield of soybean-wheat cropping system was higher during 2023-24 as compared to 2022-23 owing to higher amount and well distributed rainfall in all blocks of Tikamgarh during 2023-24. Grain yield of soybean and wheat differed significantly among different nutrient management systems (Table 5). The application of full RDF through chemical fertilizers + chemical weed control (T₃) exhibited higher grain yield of soybean and wheat followed by T₂ (50% through chemical fertilizers + 50% through FYM + chemical weed control) and T₁ (farmer's practices) during both the years of study as well as from pooled results. Pooled yield data indicated that T₃ showed yield increase of soybean and wheat by 36.2 % and 21.0 %, respectively over farmer's practice (T₁). Similarly, T₂ (50% through chemical fertilizers + 50% through FYM + chemical weed control) treatment recorded yield increase of soybean and wheat by 18.1 % and 13.9 %, respectively over farmer's practice (T₁). However, yield advantage of soybean and wheat in T₃ over T₂ was 15.3% and 6.23% respectively. Per day productivity of the soybean-wheat system was higher under treatment T₃

(24.8 kg ha⁻¹ d⁻¹) followed by T₂ (22.6 kg ha⁻¹ d⁻¹) and it was lowest in T₁ (19.6 kg ha⁻¹ d⁻¹). The highest mean wheat equivalent yield (WEY) of 57.8 q ha⁻¹ was recorded with the application of full RDF through chemical fertilizers + chemical weed control (T₃) in both soybean and wheat crops followed by T₂ (52.6 q ha⁻¹) and was the lowest with farmers practices (45.6 q ha⁻¹).

The net return (Rs. ha⁻¹) was higher in 2023-24 than 2022-23 probably due to higher grain yield of both crops in 2023-24 owing to well distributed rainfall amount. Pooled data indicated that application of full RDF through chemical fertilizers + chemical weed control (T₃) gave 39.3% and 14.8% higher net return over T₁ and T₂ treatments, respectively (Table 5). Similarly, application of 50% RDF through chemical fertilizers + 50% through FYM + chemical weed control (T₂) exhibited 21.4% higher net return over farmer's practices treatment. Application of full RDF through chemical fertilizers + chemical weed control (T₃) also registered higher per day net return (Rs. 178 ha⁻¹ d⁻¹) followed by T₂ (Rs. 155

ha⁻¹ d⁻¹) and the lowest was from farmer's practices (Rs. 128 / ha⁻¹ d⁻¹).

Mean net return per rupee invested (B: C) was higher (1.49) when crops were fertilized with full RDF through chemical

Conclusion

The trials conducted at farmer's field concluded that application of recommended doses of NPK exhibited superiority in terms of higher grain yield and net monetary return over no fertilizer application or partially applied recommended doses of fertilizers. So, the judicious use of money in right direction can pay positive results in terms of grain yield as well as additional NR/ha to the farmers. Similarly, it was evident from results that soybean-wheat system exhibited superiority over other cropping systems in Tikamgarh district of Madhya Pradesh. However, coriander crop after blackgram is more remunerative than mustard crop after blackgram. Blackgram-

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fertilizers + chemical weed control (T₃) followed by T₂ (1.34) and the lowest (1.19) was recorded under farmer's practices.

coriander system was also profitable over sesame-wheat system in Tikamgarh district. Among different agronomic management practices, application of full recommended doses of fertilizers (RDF) through chemical fertilizers + chemical weed control showed their superiority in terms of higher grain yield and net return of soybean-wheat system over farmer's practices as well as over when 50% RDF through chemicals and 50% through FYM + chemical weed control treatment in this region. Similarly, application of 50% RDF through chemicals and 50% through FYM + chemical weed control treatment was also profitable over farmer's practices.