Effectof Land Configuration on Yield, Water Use Efficiency and Economics forCropping Sequences in Dryland Area of Central India

ABSTRACT

The present investigation makes an attempt to study the effect of land configuration on yield, water use efficiency and economics for cropping sequences in dryland area ofCentral India. Different cropping sequences (*i.e.* soybean-chickpea, maize-chickpea and greengram-chickpea) were adopted under different sets of land configurations such as Furrow Irrigated Raised Bed (FIRB), Broad Bed Furrow (BBF) and Flat System as Farmer's Practices (FP). Various yield attributes such as plant height, dry matter per plant, number of branches per plant, number of podsperb/cobper plant, number of seedsper/cobper plant, 100 seed weight, seed yieldand stover yield along with Seed Equivalent Yield (SEY), gross return,and net return, Benefit Cost ratio, Rain Water Use Efficiency (RWUE) were evaluated in thise study. In case of SEY, for soybean-chickpea, maximum SEY was observed in FIRB (3197 kg ha^{-1}), followed by BBF (3131 kg ha^{-1}) and FP (2870 kg ha^{-1}). Similarly for maize-chickpea, highest SEY was detected in FIRB (3601 kg ha^{-1}), followed by BBF (3485 kg ha^{-1}) and FP (3241 kg ha^{-1}). A similar trend was obtained for greengram-chickpea where FIRB expressed highest value of SEY (2121 kg ha^{-1}) followed by BBF (2065 kg ha^{-1}) and FP (1805 kg ha^{-1}). The analysis of yield attributes along with economics clearly suggested that for all combinations of crop sequences, FIRB yielded better results over BBF and FP. The results obtained through this study clearly advocates the fact that sowing of *rabi* crops on such land configurations (FIRB and BBF) amplifies the crop yield due to the presence of residual moisture which ultimately leads to enhanced farm income.

Key words: *BBF, Cropping Sequence, Dryland, Land Configuration, Yield etc.*

1. INTRODUCTION

Kharif crops are a type of seasonal crops mainly grown with the onset of during the monsoon season in India, which usually start around June and lasts till September. These crops are suited to match India's climatic conditions during this time, which includes high temperature, rainfall and humidity.In the category of *kharif* crops, rice, soybean, maize, greengram(*moong*), pearl millet (*bajra*) and black gram (*urad*) are some of the major crops grown in almost every part of India. Besides, In dryland areas, soybean, maize and greengram are some of the prominent crops grown in *kharif* season especially in dry =land areas.

Soybean [*Glycine max* (L.)Merril] is one of the most economical and valuable legumeseed which has 25% contribution in global edible oil production. India contributes 10% in total soybean area at global level. Soybean is also known as "Golden Bean", "Miracle Crop" *etc*., because of its several

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uses.It is a high-value nutritive crop and plays a significant role in overcoming problems of food and nutritional insecurity.In the recent times, it has played a pivotal role in solving the problem of malnutrition as it contains about 20% oil and 40% high quality protein [1].

Maize [*Zea mays* L.] is an importantmultifunctional cereal crop in the *Poaceae* family. It is the third most important cereal crop in India after rice and wheat in terms of area and production. The phenomenal increase in cropped area and production of maize has been commensurate with the growth in poultry and allied industry as it is the highest contributor in poultry and animal feed due to its high energy content. Growth of starch industry is also a major contributor in fast progress of maize production as maize starch has maximum use in this industry[2]. It is used in human food, animal and poultry feed, and in industry for several purposes including maize starch, dextrose, maize syrup, and maize flakes [3]. Maize is farmed for a variety of purposes, including animal feed (silage and grains), poultry feed (grains), and pigs feed (grains), as well as for human consumption in the form of grains, sweet maize and grain maize.It grows well in a wide range of soil and climatic conditions.

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The greengram[*Vigna radiata* L.] also known as *moong* or *moong* bean is an important pulse consumed all over the world, especially in Asian countries. It has a long history of usage as traditional medicine. It is one of the most important edible legume crop, grown on more than 6 Mha worldwide (about 8.5% of the global pulse area) and consumed by most households in Asia. Due to its characteristics of relatively drought-tolerant, low-input crop, and short growth cycle (70 days or so), the greengram is widely cultivated in many Asian countries (concentrated mainly in China, India, Bangladesh, Pakistan, and some Southeast Asian countries) as well as in dry regions of SouthernEurope and warmer parts of Canada and the United States [4]. In the predominantly cereal-based diet of China and India, the greengram has been consumed as a common food for centuries. It contains balanced nutrients, including protein, dietary fiber, minerals, vitamins, and significant amounts of bioactive compounds [5]. For individuals who can't afford animal proteins or those who are vegetarian, the green gram bean is of a comparatively low-cost source of protein and has a good source of protein for them. Furthermore, green gram protein is easily digestible, as compared to protein in other legumes [6, 7].

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Rabi crops also known as winter crops are grown in the month of October or November and are then harvested in spring. These crops require frequent irrigation because they are grown in dry areas. Wheat, chickpea, and barley are some of the major*rabi* crops grown in India among which chickpea is prominently grown in dryland areas.

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Chickpea [*Cicer arietinum L.*] is the third most important pulse crop worldwide and is cultivated mainly in arid and semi-arid areas in more than fifty countries across the Mediterranean basin, Central Asia, East Africa, Europe, Australia, and North and South America [8][9]. Chickpea is mainly produced in developing countries, where more than 90% of chickpea production is consumed locally [10]. The main chickpea-producing and consuming region is the Indian subcontinent (India, Pakistan, Myanmar, Bangladesh, and Nepal), contributing almost 70% of the world's production [10]. In addition, Turkey, Australia, Ethiopia, Iran, Mexico, Canada, and the USA are other countries with high chickpea production [11].

In dryland region, many times during *kharif* season, crops suffer due to poor drainage duringgrowing stage because of heavy rain and moisture stress ~~during~~in dry spells. The *in-situ*moisture conservation practices make sure the production of crop through safe disposal of runoff or its retention for profile moisture as and when required.Excess rainfall during recent years have severely affected*kharif* crop production, therefore, thereis an urgent need to adopt new sowing techniques which can mitigate adverse effect of climate change on soybean production[12]. Most of the farmers uses seed drill for sowing of soybean on Flat System, but due to improper drainage in the field, the yield of soybean reduces drastically. The climate smart technology of sowing on changed land configuration (BBF or FIRB) have found to be effective in mitigating the adverse effect of water stress and improvement in soil physical and biological environment. Plants get benefit from the improved drainage and aeration because roots ~~gets~~getpenetrated readily. The planting of *kharif* crops on altered land configuration [Broad Bed Furrow (BBF) or Furrow Irrigated Raised Bed (FIRB) System] may reduce the deleterious effect of both extreme situations (deficit and excess) of rains as compared to traditional farming practices (Farmer's Practices or FP) [13]. *Kharif* crop can perform better under excess as well as deficit rainfall conditions if sown on ridges instead of Flat System. During *kharif* season, if different types of land configuration are adopted for crop cultivation, the soil moisture remains available for a relatively longer duration. Hence, due to the residual effect of *kharif* crops in terms of soil moisture, the yield of subsequent *rabi*crops grown (especially chickpea)

increases.Keeping such points in mind, the present investigation tries to study the effect of land configuration on yield and economics of different cropping sequence in dryland area of Central India.

2. MATERIALS AND METHODS

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2.1 Study area

The field experiment was conducted during *kharif* season of 2022-23at research field of AICRP for Dryland Agriculture, Indore,Madhya Pradesh. Three main plots as land configuration were adopted for the trial *i.e.,*M1- Sweep Blade type, M2- Broad Bed and Furrow (BBF) type and M3- Furrow Irrigated Raised Bed (FIRB)System. *Kharif* and *rabi* crops were considered as sub-plots for the trial.Split plot statistical design with three replications were applied for the experiment. Soybean (RVS-24), maize (Kanak) and greengram(Deepshikha) in *kharif* season and chickpea (RVG-202) in *rabi* season were sown for the experiment. The plot size was 10.0 m X 5.40 m.The seed rate for soybean, maize and green gram was 80 kg/ha, 20 kg/ha and 20 kg/ha respectively and row to row spacing was maintained at 45cm. 20:60:40 kg NPK as basal were applied based onrecommended dose of fertilizer.The method of hand weeding was adopted to remove weeds from cropped area. At 30 days after sowing, spraying of Chloropyrifos 50% + Cypermethilin 5%@1 lit/ha was done to control diseases. The experimental area has clayey soil(clay 59.30%, silt 30.42% and sand10.28% respectively) with soil depth from medium to deep. The soil has pH of 7.4 and contain 0.44% organic carbon. Availability of Nitrogen, Phosphorus and Potash in the soil of study area is 189 kg/ha,17.3kg/ha and 265kg/~~ha ,~~ha,respectively.

3.2 Formulas used

Following formula were used to calculate different parameter as follows:

$$\text{Net returns (₹/ha)} = \text{Gross income (₹/ha)} - \text{Total cost of cultivation (₹/ha)}$$

$$\text{B:C ratio} = \frac{\text{Gross returns (₹/ha)}}{\text{Cost of cultivation (₹/ha)}}$$

$$\text{Rain Water Use Efficiency (RWUE)} = \frac{\text{Yield (kg/ha)}}{\text{Rainfall (mm)}}$$

3. RESULTS AND DISCUSSION:

The field experiment was conducted to analyze the effect of land configurationoncroppingthree major cropping sequence of MP~~sequence~~. The results recorded in the study are presented in the ~~upcoming~~ belowsections.

3.1 Yield attributes

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The Table 1 shows the effect of land configuration on growth and yield attributesof *kharif* crops under different cropping sequences. From the table, it is evident that for soybean, maximum plant height was obtained in FIRB (67.00 cm) followed by BBF (60.56 cm) and FP (48.33 cm). In case of maize, maximum plant height was observed in FIRB (156.17 cm) followed by BBF (148.17 cm) and FP (136.67 cm). For greengram, the maximum plant height was detected in FIRB (52.11 cm) followed by BBF (49.56 cm) and FP (45.78 cm).

For soybean, maximum dry matter/plant was observed in FIRB (21.78g), followed by BBF (16.67 g) and FP (14.56 g). Similarly for maize, maximum dry matter/plant was detected in FIRB (125.00 g), followed by BBF (116.33g) and FP (97.33g). A similar trend was obtained for greengramwhere FIRB showed highest value of dry matter/plant (15.33 g) followed by BBF (13.44 g) and FP (8.44 g).

For soybean, highest number of branches per plant was observed in FIRB (4.33) followed by BBF (3.89) and FP (3.67). A similar pattern was observed in greengram (4.56 in FIRB, 3.67 in BBF and 3.33 in FP).In soybean, maximum value of number of seeds/cob per plant was obtained for FIRB (39.56)and lowest value in FP (31.00) and BBF in between them (38.56). A similar pattern was observed for maize (FIRB = 12.89, BBF = 11.11 and FP = 10.22) and greengram(FIRB = 1.30,BBF = 1.25 and FP = 1.22).

In soybean, highest value of number of seeds/cob per plant was detected in FIRB (78.00), followed by BBF (70.89) and FP (53.78). A similar trend was observed for maize (FIRB = 262.20, BBF = 249.30 and FP = 204.30) and green gram (FIRB = 46.00, BBF = 39.78 and FP = 27.00).For 100

seed weight, in soybean maximum value was noticed in FIRB (13.00 g) followed by BBF (10.33) and FP (8.00 g). Similarly for maize, maximum value was detected in FIRB (12.53 g), followed by BBF (12.00 g) and FP (10.87 g). In greengram, maximum value of 100 seed weight was obtained in FIRB (7.67 g) and least value was obtained in FP (6.33 g)whereas a moderate value (7.00 g) was obtained in BBF between FIRB and FP.

In terms of seed yield, for soybean maximum value was observed in FIRB (1475 kg ha^{-1}) followed by BBF (1382kg ha^{-1}) and FP (1239kg ha^{-1}). A similar pattern was observed for maize (FIRB = 4152kg ha^{-1}, BBF = 3994kg ha^{-1} and FP = 3644 kg ha^{-1}) and greengram(FIRB = 259 kg ha^{-1}, BBF = 246 kg ha^{-1} and FP = 225 kg ha^{-1}) as well. In case of stover yield, soybean showed maximum value in FIRB (1731kg ha^{-1}) followed by BBF (1674 kg ha^{-1}) and FP (1475 kg ha^{-1}). For maize, maximum stover yield was obtained in FIRB (5273 kg ha^{-1}), followed by BBF (5190 kg ha^{-1}) and FP (4940kg ha^{-1}). For greengram, highest value of stover yield was obtained in FIRB (685 kg ha^{-1}) and FP(685 kg ha^{-1})followed by BBF (664 kg ha^{-1}).

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Table 1. Effect of land configuration on growthand yield attributes of *kharif* cropsunder different crop sequences

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Treatments	Plant Height	Dry Matter /Plant	~~No. of~~ Branches/Plant	~~No. of~~ Pods/Cob~~/Plant~~	~~No. of~~ Seeds/ Cob~~/Plant~~	100 Seed Weight	Seed Yield	Stove Yield
	(cm)	(g)	(No.-)	(No.-)	(-)No.)	(g)	(kgha^{-1})	(kgha^{-1})
FP S1- Soybean-Chickpea	48.33	14.56	3.67	31.00	53.78	8.00	1239	1475
FP S2-Maize-Chickpea	136.67	97.33	-	1.22	204.30	10.87	3644	4940
FP S3-Greengram-Chickpea	45.78	8.44	3.33	10.22	27.00	6.33	225	685
BBF S1-Soybean-Chickpea	60.56	16.67	3.89	38.56	70.89	10.33	1382	1674
BBF S2-Maize-Chickpea	148.17	116.33	-	1.25	249.30	12.00	3994	5190
BBF S3-Greengram-Chickpea	49.56	13.44	3.67	11.11	39.78	7.00	246	664
FIRB S1-Soybean-Chickpea	67.00	21.78	4.33	39.56	78.00	13.00	1475	1731
FIRB S2-Maize-Chickpea	156.17	125.00	-	1.30	262.20	12.53	4152	5273
FIRB S3-Greengram-Chickpea	52.11	15.33	4.56	12.89	46.00	7.67	259	685

3.2 Yield and economic attributes

The Table 2 shows the effect of land configuration on yield and economics of *kharif* crops under different crop sequences. It is evident from the Table 2, that for soybean maximum crop yield was obtained under FIRB(1475kg ha^{-1}) followed by BBF (1382 kg ha^{-1}) and FP (1239 kg ha^{-1}).Similarly, in terms of productivity,maize (FIRB =4152 kg ha^{-1}, BBF =3994 kg ha^{-1} and FP =3664 kg ha^{-1}) and greengram(FIRB = 259 kg ha^{-1}, BBF = 246 kg ha^{-1} and FP = 225 kg ha^{-1}) yielded similar results.

Under FIRB, the average yield of chickpea was found as 1620.33 kg ha^{-1} followed by BBF with average yield of 1558.33 kg ha^{-1} and FP as 1453.67 kg ha^{-1}.

In case of SEY,for soybean-chickpea, maximum SEY was observed in FIRB (3197 kg ha^{-1}), followed by BBF (3131kg ha^{-1}) and FP (2870 kg ha^{-1}). Similarly for maize-chickpea, highest SEY was detected in FIRB (3601 kg ha^{-1}), followed by BBF (3485 kg ha^{-1}) and FP (3241 kg ha^{-1}). A similar trend was obtained for greengram-chickpea where FIRB expressed highest value of SEY (2121kg ha^{-1}) followed by BBF (2065kg ha^{-1}) and FP (1881kg ha^{-1}).

For different cropping sequences, maximum gross return was obtained in FIRB (soybean-chickpea =1,43,860₹ ha^{-1},maize-chickpea = 1,62,040 ₹ ha^{-1} andgreengram-chickpea = 95,460 ₹ ha^{-1}), followed by BBF (soybean-chickpea = 1,40,910 ₹ ha^{-1}, maize-chickpea = 1,56,830 ₹ ha^{-1} and greengram-chickpea = 92,940 ₹ ha^{-1}) and FP (soybean-chickpea = 1,29,155 ₹ ha^{-1}, maize-chickpea = 1,45,830 ₹ ha^{-1} andgreen gram-chickpea = 84,660 ₹ ha^{-1}).

In terms of net return, maximum net return was obtained in FIRB (soybean-chickpea = 94,860 ₹ ha^{-1}, maize-chickpea =1,13,040 ₹ ha^{-1} and greengram-chickpea = 46,460 ₹ ha^{-1}), followed by BBF (soybean-chickpea = 91,910 ₹ ha^{-1}, maize-chickpea = 1,07,830 ₹ ha^{-1} and green gram-chickpea = 43,940 ₹ ha^{-1}) and FP (soybean-chickpea = 82,155 ₹ ha^{-1}, maize-chickpea = 98,830 ₹ ha^{-1} and greengram-chickpea = 37,660 ₹ ha^{-1}).

For different cropping sequences, maximum B:C ratio was obtained in FIRB (soybean-chickpea = 2.94, maize-chickpea = 3.31 and greengram-chickpea = 1.95), followed by BBF (soybean-chickpea =2.88 ,maize-chickpea = 3.20 and greengram-chickpea = 1.90) and FP (soybean-chickpea = 2.75, maize-chickpea = 3.10 and greengram-chickpea = 1.80).

For different cropping sequences, maximum RWUE was shown by FIRB (soybean-chickpea = 1.30 kg/ha - mm, maize-chickpea = 3.72 kg/ha - mm and greengram-chickpea = 0.25kg/ha - mm) followed by BBF (soybean-chickpea = 1.24 kg/ha - mm, maize-chickpea = 3.63 kg/ha - mm and greengram-chickpea = 0.21 kg/ha - mm) and FP (soybean-chickpea = 1.13 kg/ha - mm, maize-chickpea = 3.27 kg/ha - mm and greengram-chickpea = 0.18 kg/ha - mm).

Table 2. Effect of land configuration on yield and economic of different crop sequences

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Treatments	Yield		Soybean Equivalent Yield	Gross return	Net return	B:C ratio	RWUE (*Kharif* crops)
	Kharif crops	*Rabi* crops					
	(kg ha^{-1})	(kg ha^{-1})	(kg ha^{-1})	(₹ ha^{-1})	(₹ ha^{-1})	(-)	(kg/ha - mm)
FP S1- Soybean-Chickpea	1239	1450	2870	1,29,155	82,155	2.75	1.13
FP S2-Maize-Chickpea	3644	1459	3241	1,45,830	98,830	3.10	3.27
FP S3-Greengram-Chickpea	225	1452	1881	84,660	37,660	1.80	0.18
BBF S1-Soybean-chickpea	1382	1578	3131	1,40,910	91,910	2.88	1.24
BBF S2-Maize-Chickpea	3994	1519	3485	1,56,830	1,07,830	3.20	3.63
BBF S3-Greengram-Chickpea	246	1578	2065	92,940	43,940	1.90	0.21
FIRB S1-Soybean -Chickpea	1475	1637	3197	1,43,860	94,860	2.94	1.30
FIRB S2-Maize-Chickpea	4152	1580	3601	1,62,040	1,13,040	3.31	3.72
FIRB S3-Greengram-Chickpea	259	1644	2121	95,460	46,460	1.95	0.25

The Table 3 shows the details of SEY, net returns and B:C ratio of different crop sequences. It is evident from the table, that SEY was maximum in FIRB (soybean-chickpea = 3197 kg ha^{-1}, maize-chickpea = 3601 kg ha^{-1} and greengram-chickpea = 2121 kg ha^{-1}) as compared to BBF (soybean-chickpea = 3131 kg ha^{-1}, maize-chickpea = 3485 kg ha^{-1} and greengram-chickpea = 2065 kg ha^{-1}) and FP (soybean-chickpea = 2870 kg ha^{-1}, maize-chickpea = 3241 kg ha^{-1} and green gram-chickpea = 1881 kg ha^{-1}).

Table 3. Soybean Equivalent Yield (SEY), net returns and B:C ratio of different crop sequences

Treatment	Soybean Equivalent Yield (kgha^{-1})			
	FP	BBF	FIRB	Mean
Soybean-Chickpea	2870	3131	3197	3066
Maize-Chickpea	3241	3485	3601	3442

Greengram-chickpea	1881	2065	2121	2023
Mean	2664	2894	2973	
	Land configuration	**Cropping system**		
Sem+	55	52		
CD (p=0.05)	214	161		
Net returns (₹ha^{-1})				
Soybean-Chickpea	82,155	91,910	94,860	89,642
Maize-Chickpea	98,830	1,07,830	1,13,040	1,06,567
Green Gram-chickpea	37,660	43,940	46,460	42,687
Mean	72,882	81,227	84,787	
	Land configuration	**Cropping system**		
SEm+	1646	1587		
CD (p=0.05)	6463	4891		
B:C ratio				
Soybean-Chickpea	2.75	2.88	2.94	2.85
Maize-Chickpea	3.10	3.20	3.31	3.20
Green Gram-chickpea	1.80	1.90	1.95	1.88
Mean	2.55	2.66	2.73	
	Land configuration	**Cropping system**		
SEm+	0.05	0.05		
CD (p=0.05)	0.20	0.15		

4. CONCLUSION

From the present study, it can be concluded that higher productivity with maximum net return and B:Cratio can be obtained for different cropping sequences (soybean-chickpea, maize-chickpea and greengram-chickpea) by adopting climate-smart sowing techniques such as Furrow Irrigated Raised Bed(FIRB) and Broad Bed Furrow(BBF) as compared to Flat System as Farmer's Practice. The study also demonstrated that crop sequences under FIRB perform better ~~have yielded best result as~~ compared to the corresponding crop sequences under BBF and FP. Such results clearly indicate that FIRB and BBF are the most effective land configuration methods of crop cultivation for different crop sequences as it helps in improving crop performance, optimizing resource utilization when compared with traditional farming practices. However, the results have revealed that FIRBS shows more superior results over BBF in terms of yield attributes and economics.

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