Original Research Article

Effect of Integrated Nutrient Management on Performance of Chickpea and Mustard intercropping system in Bundelkhand Region of North India

Abstract

A field experiment was carried out on crops sesame and black gram during *Kharif* 2020, and the same field INM study was carried out in *Rabi* season 2020-21 on chickpea and mustard crops. The experiments were conducted on heavy clay soil at Agriculture Research Farm, College of Agriculture, Banda University of Agriculture & Technology, Banda. The experimental design was split-plot with main factor two cropping systems viz. Sesame – Chickpea and Blackgram-Mustard and sub-factor eight integrated nutrient management viz. farmer fertilizer practice (T_1), 100 % RDF (T_2), 100% RDF + FYM (T_3), 100 % RDF + FYM + Zn (10 kg ha^{-1}) (T_4), 125 % RDF + FYM+ biofertilizer consortia (BC) (*Rhizobium spp.*, PSB and *Azotobacter spp.*) (T_5), 100 % RDF + FYM+BC (T_6), 75% RDF + FYM+BC (T_7) and 50 % RDF +FYM+BC (T_8), all treatments were replicated thrice. The FYM was applied @ 5 t ha^{-1}. The experimental results revealed that application of 125% and 100 % RDF along with FYM and biofertilizer consortia increased significantly nodule number, nodule weight per plant and number of pods per plant, thereby increased grain yield of chickpea significantly in comparison to farmers fertilizer practice (T_1), sole application of 100 % RDF (T_2) and 50 % reduction of RDF along with FYM and biofertilizer consortia (T_8).

Keyword: Chickpea, Mustard, Intercropping, Split plot design, Biofertilizer Consortia, FYM, RDF

INTRODUCTION

Soil fertility is vital for the sustainable crop production, as soil is a nonrenewable natural resource and store house of the plant nutrients. The soil fertility is deteriorated in recent competition to produce more from the unit land. Other side, the mono cropping system prevails

mostly in rainfed ecologies also adversely influenced the soil fertility due to loss of nutrient through erosion and suboptimal application of nutrients. Therefore, monitoring and maintenance of the soil fertility are important for sustainable production. Since, ignorance of the management of soil had also caused deterioration and deficiency of multi plant nutrients (both macro and micro nutrients deficiency).The soil organic carbon, nitrogen, phosphorus and Sulphur are very low to medium in most of the soils of the Bundelkhand region (Srinivasan R *et al* 2016).). Low soil organic carbon is considered as major reason of deteriorating soil productivity and affecting sustainable productivity in this soil (Ghosh *et al*., 2003;Tomar and Dwivedi, 2007; Bandy opadhyay *et al*., 2010). The application of organic manure is proven and accepted to improve the soil fertility through increasing total carbon in soils (Manna et al., 2003; Meena et al., 2015).The integrated nutrient application is crucial for maintaining higher crop productivity, sustainability of soil health and environmental quality (Narayan *et al*., 2014; Venkatesh *et al*., 2017).Integrated nutrient management is vital for sustainable productivity (Verma *et. al*., 2010) Several studies showed that the beneficial effect of INM on crop and soil productivity. India has the first rank in area and production of pulse crop in the world. The pulses are grown in 29.81-million-hectare area with the production 25.43 million tones, and productivity 852 kg ha^{-1}during 2017-18 in India (Department of Agriculture, Cooperation and Farmers Welfare, 2018).The pulse crop has rich in protein and also source of thiamin and niacin, Ca, P, and Fe etc. About 100gm of pulses give 345kcal.and per capita pulses are required is 50-60gm/day. Therefore, inclusion of pulse crop in cropping system is utmost important to produce nutritional rich food for vegetarian population. Chickpea has area 10.56 m ha with production 11.23 m tones and productivity 1063 kg ha^{-1} in India during 2017-18 (Department of Agriculture, Cooperation and Farmers Welfare, 2018). In case of Uttar Pradesh, chickpea occupied 6.11 lakh ha area, 6.84 lakh ton production with productivity 893 kg ha^{-1} during 2017-18 (Department of Agriculture, Cooperation and Farmers Welfare, 2018). Bundelkhand region recognized as a pulse bowl of the Uttar Pradesh, the region has 1.19 lakh ha area and 51.56 thousand tonnes production with productivity of 434 kg ha^{-1} during 2015-16 (FAI 2016-17). The productivity is low compare to national average as well as Uttar Pradesh.

India accounts world's 28% acreage and 20% production of mustard (Shekhawat *et al.,* 2012). Being third largest producer after Canada and China, the area, production and

productivity of this crop in India are 62.3 lakh ha, 93.4 lakh tonnes and 1499 kg ha^{-1} during 2018-19, respectively (Kalia *et. al*., 2021). It also plays vital role in Indian diet. Mustard oil contains 605 mono saturated fatty acids (42% euric acid &12% oleic acid). It has about 21% polyunsaturated fats (6% the omega -3 alpha-linolenic acid & 15% omega -6 linoleic acid) and it has about 12% saturated fats. Whereas, Uttar Pradesh, Mustard was grown in 7.53 lakh ha area, production of 11.71 lakh tonnes and the productivity of 1483 $kgha^{-1}$, respectively in year 2018-19(Kalia *et al*., 2021), while in Bundelkhand region, mustard has covered 0.708 lakh hectare area and 0.713 lakh tonnes production with average productivity is 1005 $kgha^{-1}$ during 2018-19 (Kalia *et al.,* 2021)

There is huge scope in improvement of productivity of both pulse and oilseed crops of this region through agronomic interventions along with improvement in soil fertility. The balance application of fertilizer also ensured the productivity of crops;. The challenge is to improve the land productivity and soil fertility without affecting the environment. Therefore, double crop in a year will certainly improve the fertility. However, water scare region where farmers have several constraints to improve cropping intensity. It is therefore necessary to add pulse crop for improvement of productivity and organic manures for organic carbon enhancement. The integrated use of nutrient is a proven option for restoration of the soil fertility.

Methods and Material:

The present study conducted during *Kharif* 2020 and *Rabi* season 2020-21 at Agriculture Farm entitled "Evaluation of Integrated Nutrient Management (INM) on performance of chickpea and mustard crops and soil properties" with the objective to study the effect of cropping systems and INM on growth, yield attributes and yield of chickpea and mustard crops.

The experimental site

The present experiment laid out in Agriculture Research Block, College of Agriculture during *Kharif* and *Rabi* season of 2020-21 of Banda University of Agriculture and Technology, Banda (UP). The experimental area has uniform topography. The experimental site latitude 25.528546° and longitude 80.335671° and giving an altitude of 168 m above of sea level.

The district Banda situated in Bundelkhand region of the Uttar Pradesh. The district lies on the southern fringe of Uttar Pradesh. Yamuna is joined by Ken at Chillaghat, Bageinnear Bilas, and Paisuni near Kankota villages. The total geographical area of district is 4414.10 sq. km. supporting a population of 15.37 lakh with a density of 348 persons per sq. km. District has eight blocks with 660 villages. Net sown area is 3.51 lakh ha and cropping intensity of the district is 112.2%.

The experiment was started during *Kharif* season 2020, the experimental design was randomized block design only two treatments sesame and black gram crop grown in three replications. Further from the Rabi season 2020-21 the chickpea crop was grown on sesame field and mustard was cultivated on blackgram field. The INM treatments were implemented during *Rabi* season 2020-21 as the nutrient requirement and production was higher of *Rabi* season crops. The experimental design had converted into split plot design to study the *Kharif* crop effect on economics of crop.

Source of Fertilizer: Urea (46 % N), Diammonium phosphate (DAP) (18 % N and 46 % P_2O_5) and Muriate of Potash (MOP) (60 % K_2O) and $ZnSO_4.7H_2O$ were used as inorganic source of fertilizer. Chickpea crop received all the inorganic fertilizer as a basal application as per the treatments. While fertilizers applied in mustard crop ½ half of nitrogen, full amount of DAP and MOP at the time of basal application and remaining nitrogen dose in form of urea top dressed in two splits.

The FYM was applied to the Rabi season crops as the selected *Rabi* season crops were more fertilizer requirement than *Kharif* season crops. The FYM (25 % moisture; 0.50 % Nitrogen; 0.25 % P_2O_5 and 0.5 % K_2O) was applied 15 days before at 25 percent moisture content in designated plots as per the treatment.

The liquid biofertilizer consortia (Rhizobium spp., Azotobacter and Phosphorus solubilizing bacteria spp.) applied rate of 1000 ml per hectare, the consortia was mixed with FYM and incubated overnight and next day applied to plots (both chickpea and mustard) as per the treatments.

Table 1: Amount of nutrient applied in different treatments (kg ha^{-1})

	Nutrients added through Fertilizers (kg ha^{-1})				Nutrients added through FYM (kg ha^{-1})			Total Nutrients applied (Fertilizer + FYM) (kg ha^{-1})			
	Nitrogen (N)	Phosphorus (P2O5)	Potassium (K2O)	Zinc (Zn)	Nitrogen (N)	Phosphorus (P2O5)	Potassium (K2O)	Nitrogen (N)	Phosphorus (P2O5)	Potassium (K2O)	Zinc (Zn)
Chickpea											
T1	18	46	-	-	-	-	-	18.0	46.0	-	-
T2	20	60	20	-	-	-	-	20.0	60.0	20.0	-
T3	20	60	20	-	25	12.5	25.0	45.0	72.5	45.0	-
T4	20	60	20	10	25	12.5	25.0	45.0	72.5	45.0	10
T5	25	75	25	-	25	12.5	25.0	50.0	87.5	50.0	-
T6	20	60	20	-	25	12.5	25.0	45.0	72.5	45.0	-
T7	15	45	15	-	25	12.5	25.0	40.0	57.5	40.0	-
T8	10	30	10	-	25	12.5	25.0	35.0	42.5	35.0	-
Mustard											
T1	60	40	-	-	-	-	-	60.0	40.0	-	-
T2	80	40	40	-	-	-	-	80.0	40.0	40.0	-
T3	80	40	40	-	25	12.5	25.0	105.0	52.5	65.0	-
T4	80	40	40	10	25	12.5	25.0	105.0	52.5	65.0	10
T5	100	50	50	-	25	12.5	25.0	125.0	62.5	75.0	-
T6	80	40	40	-	25	12.5	25.0	105.0	52.5	65.0	-
T7	60	30	30	-	25	12.5	25.0	85.0	42.5	55.0	-
T8	40	20	20	-	25	12.5	25.0	65.0	32.5	45.0	-

Results and Discussion:

Effect of integrated nutrient management on growth, yield attributes and yield of chickpea crop.

Plant stand and periodic interval plant height data are given in table no.2 and the uniform plant stand was recorded in all the plots. There was no statistically difference in plant stand. The effect of alone and combined application of fertilizer, FYM and biofertilizer consortia (BC) did not influence the plant height irrespective of days.

Integrated nutrient application had positive impact on number of nodules per plant. The nodule number per plant varied from 11.9 to 16.8 in 100 % applications of RDF (T_2) and 125 % RDF+ 5 t ha^{-1} FYM + biofertilizer consortia (T_5) treatment. The T_5 and T_6 treatments had almost similar number of nodules per plant and significantly superior than remaining treatments. The T_5 had 34.4 % and 41.2 % higher than respective control T_1 and T_2 respectively. Remaining other treatments were statistically similar number of nodules.

On perusal of data crop biomass was found non-significant at 30 DAS, At 60 DAS, the effect was remarkable and higher biomass recorded with the 125 % RDF + 5 t ha^{-1} FYM + biofertilizer consortia (T_5) followed by 100 % RDF + 5 t ha^{-1} FYM + biofertilizer consortia (T_6), both the treatments were statistically at par with each other. Similar trend was observed at 90 DAS, the plant biomass varied from 18.3 to 23.8 q ha^{-1} in farmer fertilizer practice (T_1) and 125 % RDF + 5 t ha^{-1} FYM + biofertilizer consortia (T_5) treatments, respectively

The highest (110.0) number of pods per plant was recorded with 125 % RDF + 5 t ha^{-1} FYM + biofertilizer consortia (T_5),Data on 100 seed weight reveals that all the treatments had similar effect on test weight. T_5 had numerically more test weight followed by T_8

Table 2. Effect of different treatments on growth parameters of chickpea crop.

Treatment		Plant height (cm)			Plant biomass qha^{-1}			Nodules plant^{-1} (No)			No of pod plant^{-1}	Nodule weight (mg plant^{-1})		
		30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS		30 DAS	60 DAS	90 DAS
T_1	Farmer fertilizer practice (FFP)	9.8	28.0	42.0	1.08	5.4	18.3	4.8	12.5	31.8	91.3	59.2	172.3	609.2
T_2	100 % RDF	12.2	30.4	44.7	1.14	5.5	20.2	5.9	11.9	33.8	99.7	58.6	179.9	612.3
T_3	100 % RDF + 5 t ha^{-1} FYM	11.2	28.6	44.5	1.17	5.9	21.2	5.3	10.7	33.6	103.1	63.3	180.8	661.0
T_4	100 % RDF + 5 t ha^{-1} FYM + {Zinc @10 kg ha^{-1}}	11.9	26.9	41.5	1.19	6.3	21.4	4.4	11.1	33.9	104.7	52.3	177.8	625.6
T_5	125 % RDF + 5 t ha^{-1} FYM + BC	12.8	33.9	50.7	1.18	7.4	23.8	4.5	16.8	41.6	110.0	61.2	269.3	793.1
T_6	100 % RDF + 5 t ha^{-1} FYM + BC	11.0	29.2	44.0	1.15	6.7	23.4	4.6	16.7	42.4	106.2	55.7	266.7	738.5
T_7	75 % RDF + 5 t ha^{-1} FYM + BC	12.0	32.1	42.2	1.15	6.2	21.7	4.3	13.0	37.7	97.5	56.2	208.9	634.1
T_8	50 % RDF + 5 t ha^{-1} FYM + BC	11.7	29.5	44.5	1.04	5.4	19.2	5.7	12.1	37.9	91.0	58.1	193.8	629.5
SE(d)±		1.4	2.2	4.0	0.1	0.4	1.5	0.9	1.5	2.9	4.0	9.8	19.9	44.0
C.V.		15.0	9.0	11.0	7.0	8.7	8.9	22.2	13.8	9.7	4.9	20.6	11.8	8.1
CD(P=0.05)		NS	NS	NS	NS	0.9	3.3	NS	3.2	6.2	8.6	NS	43.1	95.2

Grain yield

The Data pertaining to effect of integrated application of fertilizer, FYM and biofertilizer and sole application of fertilizer on yield component is summarized in table 3.

On perusal of data, it is evident that different treatments positively influenced the grain, biological yield and harvest index of chickpea crop. The highest grain yield (26.7 q ha^{-1}) was obtained with 125 % RDF + 5 t ha^{-1} FYM + biofertilizer consortia (T_5) followed by the 100 % RDF + 5 t ha^{-1} FYM + biofertilizer consortia (T_6) (26.1 q ha^{-1}). Both these treatments were statistically comparable with each other. T_5 and T_6 treatments were produced remarkable higher yield over the farmer fertilizer practice (T_1), 100 % RDF (T_2) and 50 % RDF + 5 t ha^{-1} FYM + biofertilizer consortia (T_8), respectively. The T_3, T_4, T_5, T_6, T_7 treatments were statistically at par with each other. T_5 had 40.5%, 27.8 % and 29 % higher over the T_1, T_2 and T_8 treatments, respectively, while T_6 had 37.4 %, 24.9 % and 26.1 % statistically higher than T_1, T_2 and T_8, respectively.

Straw yield

Although the similar trend recorded with the straw yield, however, the different treatments did not influence statistically the straw yield of the chickpea crop. The numerically more straw yield (33.8 q ha^{-1}) was obtained with T_5 (125 % RDF + 5 t ha^{-1} FYM + biofertilizer consortia) followed by the T_7 (75 % RDF + 5 t ha^{-1} FYM + biofertilizer consortia) treatment.

Biological yield

The effect of different treatments on biomass yield was pronounced and trend was similar to grain yield. The highest biological yield (60.5 q ha^{-1}) was recorded with T_5 (125 % RDF + 5 t ha^{-1} FYM + biofertilizer consortia) followed by the (57.2 q ha^{-1}) T_6 (100 % RDF + 5 t ha^{-1} FYM + biofertilizer consortia) treatments. Both the treatments were statistically at par with each other and notable effect in comparison to T_1, T_2 and T_8 treatments. The T_5 had produced 27.9 %, 21.0 % and 19.1 % higher yield over the treatments T_1, T_2 and T_8, while T_6 had produced 20.9 %, 14.4 % and 12.6 % maximum yield than T_1, T_2 and T_8 treatments, respectively. T_3 and T_4 also had significantly higher yield than farmer's fertilizer practice treatment.

Harvest Index (HI)

Harvest index of chickpea crop also influenced by the application of integrated nutrients. Data revealed that the highest harvest index (45.6) was found with T_6 (100 % RDF + 5 t ha^{-1} FYM + biofertilizer consortia) treatment followed by the (45.6) T_5 (125 % RDF + 5 t ha^{-1} FYM + biofertilizer consortia) treatment, both these treatments were statistically at with each other and T_3, T_4 and T_7. T_6 gave 13.7 %, 10.4 % and 11.5 % higher HI than T_1, T_2 and T_8, respectively.

Table 3: Effect of integrated nutrient management on grain yield, straw yield, biological yield, (q ha^{-1}) and harvest index of chickpea crop.

Treatments		Grain Yield (q ha^{-1})	Straw Yield q ha^{-1})	Biological Yield (q ha^{-1})	Harvest Index (%)
T_1	Farmer fertilizer practice (FFP)	19.0	28.3	47.3	40.1
T_2	100 % RDF	20.9	29.7	50.6	41.3
T_3	100 % RDF + 5 t ha^{-1} FYM	24.6	30.7	55.4	44.5
T_4	100 % RDF + 5 t ha^{-1} FYM + {Zinc @10 kg ha^{-1}}	24.6	30.4	55.0	44.7
T_5	125 % RDF + 5 t ha^{-1} FYM + BC	26.7	33.8	60.5	44.2
T_6	100 % RDF + 5 t ha^{-1} FYM + BC	26.1	31.2	57.2	45.6
T_7	75 % RDF + 5 t ha^{-1} FYM + BC	24.8	32.2	57.0	43.5
T_8	50 % RDF + 5 t ha^{-1} FYM + BC	20.7	30.0	50.8	40.9
SE(d)±		1.3	1.5	2.5	1.4
C.V.		6.9	6.1	5.6	3.9
CD(P=0.05)		2.9	NS	5.4	3.0

Effect of integrated Nutrient management on growth, yield attributes and yield of mustard crop.

Data reveals that plant stand (sqm) was uniform and there is no effect of integrated nutrient management on plant stand.

Plant height of mustard plant increased with number of days, irrespective of treatments. However, effect of different treatments on plant height was non-significant, Although, 125 % RDF + 5 t ha^{-1} FYM + biofertilizer consortia (T_5) had longer mustard plants followed by the 100 % RDF + 5 t ha^{-1} FYM + biofertilizer consortia (T_6) treatment irrespective of the number of days. At 30 DAS the plant highest varied from 10.5 to 12.0 cm in T_4 and T_5 - T_6.

Whereas at 60 DAS, the minimum height (42.1 cm) of plant was recorded with T_4 treatment and maximum plant height (55.3 cm) was recorded with T_5 treatment. At 90 DAS, the longest plant highest (161.0 cm) was recorded with 125 % RDF + 5 t ha^{-1} FYM + biofertilizer consortia (T_5) and smallest plant (149.3 cm) was observed with 50 % RDF + 5 t ha^{-1} FYM + biofertilizer consortia (T_8) treatment.

Data reveals that irrespective of treatment crop biomass improved from 30 to 90 days. At 30 DAS, the different treatment was not affected the biomass statistically. It was varied from 0.27 to 0.33 q ha^{-1} in T_8 and T_4 treatments. At 60 DAS, the neither sole application of fertilizer nor combined application of organic, inorganic and biofertilizer consortia influenced the crop biomass. The numerically maximum biomass (12.5 q ha^{-1}) was recorded with 125 % RDF + 5 t ha^{-1} FYM + biofertilizer consortia (T_5) followed by 100 % RDF + 5 t ha^{-1} FYM + Zn (T_4) and minimum biomass (10.1 q ha^{-1}) was recorded with farmer fertilizer practice plot (T_1). At 90 DAS.

The number of siliqua was varied from 173.1 to 228.5 in farmers fertilizer practice (T_1) and 125 % RDF + 5 t ha^{-1} FYM + biofertilizer consortia (T_5) treatments, respectively. The test weight of mustard crop was not influenced by the different treatments. The maximum test weight (5.93 gm) was recorded with 125 % RDF + 5 t ha^{-1} FYM + biofertilizer consortia (T_5)

Table 4. Effect of different treatments on growth parameters of mustard crop.

Treatment		Plant height (cm)			Plant biomass qha^{-1}			No of siliqua plant^{-1}
		30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	
T_1	Farmer fertilizer practice (FFP)	12.0	42.2	151.3	0.29	9.4	46.6	173.1
T_2	100 % RDF	10.7	47.4	153.9	0.28	10.6	48.7	192.1
T_3	100 % RDF + 5 t ha^{-1} FYM	10.7	56.2	158.1	0.30	10.6	51.3	200.8
T_4	100 % RDF + 5 t ha^{-1} FYM + {Zinc @10 kg ha^{-1}}	10.5	42.1	159.3	0.33	11.9	51.2	202.2
T_5	125 % RDF + 5 t ha^{-1} FYM + BC	12.0	55.3	161.0	0.30	12.5	57.0	228.5
T_6	100 % RDF + 5 t ha^{-1} FYM + BC	12.0	53.8	158.3	0.29	11.6	54.6	219.7
T_7	75 % RDF + 5 t ha^{-1} FYM + BC	10.7	52.9	151.9	0.31	11.0	51.4	196.0
T_8	50 % RDF + 5 t ha^{-1} FYM + BC	8.4	43.3	149.3	0.27	10.1	49.4	181.5
SE(d)±		1.9	10.8	9.3	0.06	1.0	2.7	14.51
C.V.		20.5	27.0	7.3	24.2	10.9	6.4	8.92
CD(P=0.05)		NS	NS	NS	NS	NS	5.8	31.43

Grain yield

The data pertaining effect of integrated nutrient management on grain yield, straw yield, biological yield and harvest index is given in table 5.

On perusal of data, it is evident that different treatments positively influenced the grain yield of mustard. Grain yield was varied from 19.6 to 26.3 q ha^{-1} in T_1 (farmer fertilizer practice) and T_5 (125 % RDF + 5 t ha^{-1} FYM + biofertilizer consortia) treatments, respectively. The T_5 and T_6 treatments produced statistically similar grain yield and both were significantly superior yield than T_1, T_2 and T_8, respectively. T_5 had 34.2 %, 21.4 % and 21.0 % higher than T_1, T_2 and T_8 while T_6 had 32.1 %, 21.4 % and 21% statistically higher than T_1, T_2 and T_8, respectively. T_3-T_7 treatments were statistically similar with each other.

Straw yield

The effect of integrated nutrient management on Straw yield was observed non significant. While, application of 125 % RDF + 5 t ha^{-1} FYM + biofertilizer consortia (T_5) and 100 % RDF + 5 t ha^{-1} FYM + biofertilizer consortia (T_6) treatment were produced almost similar straw yield i.e., 53.7 and 53.6 q ha^{-1}. The minimum straw yield was recorded with control i.e., farmer fertilizer practice (T_1).

Biological yield

The effect of different treatments on biomass yield of mustard crop was found to be significant. The highest biomass yield (80 q ha^{-1}) had produced by the 125 % RDF + 5 t ha^{-1} FYM + biofertilizer consortia (T_5) treatment followed by 100 % RDF + 5 t ha^{-1} FYM + biofertilizer consortia (T_6) treatment. Both treatments were at par with each other and notable high biomass over the T_1, T_2 and T_8, treatments. However, T_3-T_6 treatments were statistically at par with each other. T_5 had 20.7%, 16.3 % and 18.2 % high biomass than farmer fertilizer practice (T_1), 100 % RDF (T_2) and 50 % RDF + 5 t ha^{-1} FYM + biofertilizer consortia (T_8), respectively.

Harvest Index

The effect of different treatments on harvest index of mustard was non-significant. The more harvest had obtained with 100 % RDF+ FYM+ Zn (T_4) treatment, while the minimum HI was found with farmer fertilizer practice (T_1) treatment.

Table 5: Effect of integrated nutrient management on grain yield, straw yield, biological yield, (q ha^{-1}) and harvest index of mustard crop.

Treatments		Grain Yield (q ha^{-1})	Straw Yield (q ha^{-1})	Biological Yield (q ha^{-1})	Harvest Index (%)
T_1	Farmer fertilizer practice (FFP)	19.6	46.6	66.3	29.7
T_2	100 % RDF	21.4	47.4	68.8	31.1
T_3	100 % RDF + 5 t ha^{-1} FYM	24.6	51.9	76.5	32.2
T_4	100 % RDF + 5 t ha^{-1} FYM + {Zinc @10 kg ha^{-1}}	25.3	51.6	76.9	32.9
T_5	125 % RDF + 5 t ha^{-1} FYM + BC	26.3	53.7	80.0	32.8
T_6	100 % RDF + 5 t ha^{-1} FYM + BC	25.9	53.6	79.5	32.6
T_7	75 % RDF + 5 t ha^{-1} FYM + BC	23.5	49.9	73.3	32.0
T_8	50 % RDF + 5 t ha^{-1} FYM + BC	21.0	46.7	67.7	31.1
SE(d)±		1.2	3.0	3.1	1.8
C.V.		6.4	7.2	5.1	7.0
CD(P=0.05)		2.7	NS	6.7	NS

Effect of cropping system and integrated nutrient management on chickpea equivalent yield and economic indices

Data indicated that interaction effect of main factor and sub factor was found non-significant. Similarly, the main factor also had statistically similar equivalent yield. Whereas,

integrated nutrient management had remarkable effect on mean grain yield. The application of T_5 (125 % RDF + 5 t ha^{-1} FYM + Biofertilizer consortia) had produced (25. 29 q ha^{-1}) mean yield followed by the T_6 (100 % RDF + 5 t ha^{-1} FYM + Biofertilizer consortia) (24.79 qha^{-1}). These two treatments were similar in mean equivalent yield and had notable increase in farmer fertilizer practice (T_1), 100 % RDF (T_2) and T_8 (50 % RDF + 5 t ha^{-1} FYM + Biofertilizer consortia) treatments. T_1, T_2 and T_7 were 37.5 %, 25.5 % and 27.2 % lower than T_5 and 34.8 %, 23.0 % and 24.7 % lower than T_6, respectively. Further, the addition of FYM with 100 % RDF (T_3), and T_4, 125 %, 100 % and 75 % RDF and biofertilizer i.e. T_5, T_6 and T_7 were statistically similar mean equivalent yield.

Table 6: Effect of cropping system and integrated nutrient management on chickpea yield and chickpea equivalent yield.

Treatments		Main factor		Mean Yield ($q\ ha^{-1}$)
		Sesame-Chickpea	Urdbean-Mustard	
		Chickpea yield ($q\ ha^{-1}$)	Chickpea equivalent yield ($q\ ha^{-1}$)	
T_1	Farmer fertilizer practice (FFP)	18.97	17.82	18.39
T_2	100 % RDF	20.88	19.41	20.15
T_3	100 % RDF + 5 t ha^{-1} FYM	24.63	22.31	23.47
T_4	100 % RDF + 5 t ha^{-1} FYM + {Zinc @10 kg ha^{-1}}	24.57	22.98	23.77
T_5	125 % RDF + 5 t ha^{-1} FYM + BC	26.72	23.86	25.29
T_6	100 % RDF + 5 t ha^{-1} FYM + BC	26.08	23.49	24.79
T_7	75 % RDF + 5 t ha^{-1} FYM + BC	24.77	21.29	23.03
T_8	50 % RDF + 5 t ha^{-1} FYM + BC	20.73	19.03	19.88
Average		23.42	21.27	

Factor A (CD@ 5%)	NS	SE (d)	0.54
Factor B (CD@ 5%)	1.78	SE (d)	0.87
Interaction A x B (CD@ 5%)	NS	SE (d)	1.23

Economic indices:

Cost of cultivation

It is evident from the data cost of nutrient was minimum in farmer fertilizer practice (T_1) treatment in both the chickpea and mustard and maximum in treatment 125 % RDF + 5 t ha^{-1} FYM + biofertilizer consortia (T_5). Similarly, the cost of cultivation was minimum with farmer fertilizer practice (T_1) treatment and maximum in treatment 125 % RDF + 5 t ha^{-1} FYM + biofertilizer consortia (T_5) in both the chickpea and mustard. In general, it is evident that addition of FYM treatments had higher cost of nutrient as well cost of cultivation than sole application of the fertilizer.

Gross return

On perusal of the data, there was no interaction effect on net return. The main factor sesame-chickpea cropping system had significantly higher gross return irrespective of INM than Blackgram-mustard crop. It had 16.0 % higher than Blackgram-Mustard cropping system. The application of INM irrespective of cropping system was influenced gross return. The significantly highest gross return (Rs 126652/-) was obtained with 125 % RDF + 5 t ha^{-1} FYM + biofertilizer consortia (T_5) followed by the 100 % RDF + 5 t ha^{-1} FYM + biofertilizer consortia (T_6) treatment. Both the treatment had significant effect on gross return than T_1, T_2, and T_8, respectively. T_3-T_7 was statistically at par with each other.

Net return

It is apparent from the data there was no interaction effect on net return. The main factor sesame-chickpea cropping system had significantly higher net return irrespective of INM than Blackgram-mustard crop. It had 15.5 % higher than Blackgram-Mustard cropping system. The application of INM irrespective of cropping system was influenced net return. The significantly

highest net return (Rs 94934/-) was fetched with 125 % RDF + 5 t ha^{-1} FYM + Biofertilizer consortia (T_5) followed by the 100 % RDF + 5 t ha^{-1} FYM + Biofertilizer consortia (T_6) treatment. Both the treatment had notable effect on net return than T_1, T_2, T_7 and T_8, respectively. T_3-T_6 was statistically at par with each other.

B:C ratio

On perusal of data, it is clearly indicated that there was no interaction effect between the cropping system and integrated nutrient management on Benefit: cost ratio (B:C). Similarly, main factor did not influenced the B:C ratio. Only integrated nutrient management had significant effect on B:C ratio. The highest B:C ratio (3.05) was obtained with 100 % RDF + 5 t ha^{-1} FYM + Biofertilizer consortia (T_6) treatment followed by 125 % RDF + 5 t ha^{-1} FYM + Biofertilizer consortia (T_5) irrespective of the crop, both the treatments were at par with each other and remarkable effect on B:C ratio in comparison to farmer fertilizer practice (T_1) and 50 % RDF + 5 t ha^{-1} FYM + Biofertilizer consortia (T_8). However, (T_6) was at par with T_3, T_4, T_5 and T_7, respectively. T_6 had 16.2 % 12.1% and 19.0 % significantly B:C ratio than T_1, T_2 and T_8. It was evident the application of biofertilizer consortia with RDF and FYM increased B:C ratio except T_8.

Table 7 : Effect of cropping system and integrated nutrient management on Gross return, Net return, B.C. ratio of chickpea and mustard crop.

Treatment		Gross return (₹)	Net return (₹)	Benefit- Cost ratio (₹)
T_1	Farmer fertilizer practice (FFP)	92498	66363	2.54
T_2	100 % RDF	101182	73535	2.66
T_3	100 % RDF + 5 t ha^{-1} FYM	117500	87354	2.90
T_4	100 % RDF + 5 t ha^{-1} FYM + {Zinc @10 kg ha^{-1}}	118934	86993	2.73
T_5	125 % RDF + 5 t ha^{-1} FYM + BC	126652	94934	2.99
T_6	100 % RDF + 5 t ha^{-1} FYM + BC	123960	93338	3.05
T_7	75 % RDF + 5 t ha^{-1} FYM + BC	115472	85946	2.90
T_8	50 % RDF + 5 t ha^{-1} FYM +	99930	71500	2.52

	BC			
Mean				
Factor A (CD@ 5%)		2,685	2,685	0.1
Factor B (CD@ 5%)		4,285	4,285	0.1
Interaction A x B (CD@ 5%)		6,059	6,059	0.2

Conclusions

The study concludes that conjunctive use of fertilizer (125 % or 100 % RDF), FYM and biofertilizer consortia had positively influenced the chickpea and mustard crops. Thus, the application of 100 % RDF along with 5 t ha^{-1} FYM and biofertilizer consortia is suggested for better growth and enhancing yield attributes of chickpea and mustard crops.

Although the addition of FYM has increased the cost of fertilizer, thereby cost of cultivation, the combination of 125 % RDF with 5 t ha^{-1} FYM and biofertilizer consortia (T_5) had a better gross return. The net return is at par with 100 % RDF along with 5 t ha^{-1} FYM and biofertilizer consortia (T_6) than the sole application of fertilizer in FFP, 100 % RDF. Further, the B:C ratio was better with 100 % RDF along with 5 t ha^{-1} FYM and biofertilizer consortia. It is therefore, can be recommended to farmers after the validation on the farmer fields. The study also suggests that reducing the 50 % fertilizer even with FYM and biofertilizer can be detrimental as it has adversely affected the crop performance and minimum B:C ratio in the first year of cultivation.

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