Original Research Article

Sorghum-based intercropping system as influenced by organic manuring under rainfed condition

Abstract

A field experiment was conducted during *kharif* season of 2017 at Soil Conservation and Water Management Farm of the Chandra Shekhar Azad University of Agriculture and Technology, Kanpur to find out effect of cropping systems and doses of FYM on growth, yield, water use efficiency, splash loss and economics of crops under rainfed condition. The treatments comprised of 4 cropping systems i.e. (i) sole sorghum, 45 cm apart (ii) sole greengram, 45 cm apart (iii) sorghum + greengram (2:1 row ratio) (iv) sorghum + greengram (3:1 row ratio) and 3 doses of FYM i.e. (i) without FYM (ii) 10 t / ha (iii) 20 t / ha were tested in Randomized block design with 3 replications. Results obtained that the yield of sorghum and greengram were highest in their sole stands. The yield of sole and intercropped greengram in terms of sorghum equivalent grain yield showed significant variation, whereas sorghum + greengram (2:1 row ratio) brought out significantly the highest production as compared to other cropping systems. Moreover, the land equivalent ratio, water use efficiency, gross return and net return were also found to be the highest. Simultaneously, maximum splash loss was observed under sole sorghum and minimum under greengram treatment. Increasing rates of FYM brought out significant improvement in vegetative growth, yield attributes and grain / stover yield, where a dose of 10 t FYM/ha gave best performance in respect of vegetative growth, yield attributes and grain / stover yield. In addition, net return was also noticed higher, but splash loss was lower.

Comment [RM1]: Add background, problems, aims, and novelty.

Keywords:*Sorghum, Greengram, water use efficiency, Consumptive water use, Soil moisture content*

Introduction

Rainfed agriculture accounts for 80% of global cultivation and ensures food security. Poverty, malnutrition, water scarcity, land degradation, and poor physical and social infrastructure threaten these areas. However, low soil nutrient capacity and low fertilizer use also limit crop production in rainfed areas. Stabilizing and increasing crop production in these areas requires crop management options that efficiently use soil nutrients and moderate nutrient inputs while reducing risk. Under rainfed conditions, integrated nutrient management improves soil fertility, productivity, water use efficiency, and physical, chemical, and biological properties (Pandey *et al*., 2013).Crop planning depends on rainwater availability, dry and wet spells, and water surplus and deficit. Farming systems need cropping systems. It shows cropping patterns and farm resources. Cropping pattern is the percentage of land under different crops at a given time. Intercropping involves planting two or more crops in rows on the same land. Intercropping aims to increase productivity per unit area and production stability. Intercropping usesproductively use resources. Rainfed soils are precariously low in fertility due to runoff water washing nutrients and crop application of organic manures and fertilizers. Due to fertilizer shortages, the situation will likely persist. We must emphasize organic manures and legumes in cropping systems.Climate change will strain Indian water resources. Climate affects water demand, supply, and quality. In arid and semi-arid areas, climate change will increase competition for water use for economic, social, and environmental purposes. Water resources are unevenly distributed in space and time (Mall *et al*., 2007).Sorghum (*Sorghum bicolor* L.) is a global staple crop. Sorghum is a staple for millions in Africa and Asia. It also feeds millions of animals that provide human food. Sorghum grain has 10.4% protein, 1.9% fat, 72.6% carbohydrates, and 1.6% mineral matter, so it can replace other grains in dairy, poultry, and swine diets. It's also used in US and other developed nations' industries as raw material. Portable alcohol, fuel alcohol, starch jiggery, and bakery products like buns, bread, cakes, cookies, and biscuits are sold. Sorghum's best trait is drought resistance.Sorghum, the fourth most important cereal, is grown on 43.7 million hectares. India has the most sorghum acreage but the second-most production, behind the US. China, Nigeria, Sudan, and Argentina are major sorghum producers. Sorghum (jowar) is our third largest food crop. It produces 4.41 million tonnes in India on 5.65 million hectares at 7.8 q/ha. Maharashtra, Karnataka, Rajasthan, Tamil Nadu, Madhya Pradesh, Andhra Pradesh, Uttar Pradesh, and Gujarat are major sorghum producers. It is grown on 1.6 lakh hectares in Uttar Pradesh and yields 1.1 lakh tonnes per year at 6.77 q/ha (Anonymous, 2015-16).India's third-most-important legume crop is greengram. Greengram fixes atmospheric nitrogen and improves soil fertility in India. It is a small herbaceous annual drought-tolerant crop used as an intercrop in dryland farming. Being a short-duration (60–65 days) crop with wild adaptability, grown worldwide as a sole crop and as an intercrop or mixed crop with cereals. Sorghum + greengram intercropping was more productive, profitable, and soil moisture efficient than sorghum and greengram alone, according to Budher and Tamilselvan (2003) and Dar *et al*. (2003). Rajasthan, Maharashtra, Karnataka, Odisha, Madhya Pradesh, Tamil Nadu, Bihar, Andhra Pradesh, Gujarat, and Telangana produce 2.07 million tonnes of greengram on 4.31 million hectares with 4.81 q/ha productivity. It is grown on 0.93 lakh hectares in Uttar Pradesh and yields 0.49 lakh tones per year at 5.29 q / ha (Anonymous, 2016-17).In intercropping systems, additive and replacement series are based on the percent of plant stand used for each crop. The base crop is sown with 100% of its recommended stand in additive series, which is most popular in India. Adjusting crop geometry adds intercrop to the base crop. Intercrop stands below its sole stand recommendation. Replacement series crops are component crops. One component is sacrificed to introduce another.Intercropping improves land use efficiency, crop productivity, and financial returns. Intercropping maximises solar energy and crop association benefits. In widespread crop and stress environments, these benefits are usually greater. Mixture densities and crop proportions affect intercropping system yields and efficiency (Reddy, 2004).FYM is plant-nutrient rich. It feeds soil microorganisms and decomposes to dissolve soil minerals (Sharma and Guled, 2011). FYM promotes soil granulation and increases water holding capacity and permeability. Keeping in view of all above facts and need of cereal and pulses for burgeoning population of the country, the present study entitled, “Sorghum - based intercropping system as influenced by organic manuring under rainfed condition” was undertaken during *kharif*season of 2017 at Soil Conservation and Water Management Farm of C. S. Azad University of Agriculture and Technology, Kanpur with the following objectives: To study the growth and yield behavior of different row crop adjustments as influenced by organic manuring, to study on water use and water use efficiency under different intercropping systems, to study the effect of different row crop adjustments under various treatments on splash loss.

Material and method

Location:
The experiment was laid out at Soil Conservation and Water Management Farm which is situated just adjacent to main Campus of University in the Gangetic alluvial plain zone of Central Uttar Pradesh. It lies between 25o 26' and 26o 58' North latitude and 79o 31' and 80o 34' East longitude.

Climate and Weather:
Kanpur district falls in the sub-tropical zone having semi-arid climate with average annual rainfall of about 800 mm, the most of which is received during the monsoon season of between last week of June to end of September with occasional showers in winter months. May and June are hottest months when day temperature rises up to 45^oC while January is coldest when night temperature falls to 4^oC. The weather parameters prevailed during experimental crop period were collected from "Meteorological Observatory of the University".

Experimental Soil:
The soil of the experimental field was a typical Gangetic alluvium falling under the textural class sandy loam. After field operation, soil samples were drawn randomly at 5 places in whole experimental area from 0-15 cm depth before sowing. The soil of all 5 samples was mixed together thoroughly and a composite representative soil sample was prepared to analysis for their physical, physico-chemical and chemical properties.Water holding capacity (%)29.1, Wiltingpoint (%)6.2, P^H 7.8, Electrical conductivity (dS m^{-1} at 25 ^oC) 0.44,Organic carbon (%) 0.32, Available-N (169.5 kg/ha), Available P_2O_5 (17.4 kg/ha), Available K_2O (172.6 kg/ha).

Treatments :
The treatments comprised 12 combinations of 4 cropping systems and 3 doses of FYM as given below: Cropping systems – 4 : C1 = Sole sorghum, 45 cm apart C2 = Sole greengram, 45 cm apart C3 = Sorghum + greengram (2:1 row ratio) C4 = Sorghum + greengram (3:1 row ratio), (B) Doses of FYM – 3, D0 = Control (without FYM) D1 = 10 t/ha, D2 = 20 t/ha. The experiment was laid out in a Factorial randomized block design with 3 replications.

Observation on crop

plant Stand:
It was recorded twice, once after thinning operation for initial plant stand and again at crop maturity for final plant stand ('000/ha). In both observations, number of plants per metre row length were counted randomly at 3 places in each plot. Then, the values were converted into plants/ha by proper calculations. Counting of plants was done separately for each component crop of intercropping system.

Plant Height:
It was recorded at successive growth stages of 30, 60, 90 DAS and at maturity of sorghum while plant height of greengram was recorded at 30 DAS and at maturity. For this purpose, 3 plants of each crop in all treatments were selected at random and tagged. The height of tagged plants was measured from ground level up to the base of top most fully unfurled leaf of sample plant. Mean for each plot crop was computed and recorded as mean plant height in centimeters.

Days to Flowering and Maturity:
These observations were taken visually. The dates of more than 5% flowering of each crop plants were recorded plot-wise while maturity date was recorded when more than 90% maturity was observed. Then, number of days to flowering and maturity were calculated on the basis of sowing date in all component crops.

Soil Moisture Estimation:

Soil samples were collected with the help of Screw auger from a depth of 100 cm in four successive layers viz., 0-25, 25-50, 50-75 and 75-100 cm from each treatment in one replication from sowing till harvest of the crop i.e. at sowing time, 30, DAS and at harvest time in greengram crop but at sowing time, 30, 60, 90 DAS and at harvest time in sorghum crop and soil moisture was estimated gravimetrically. The soil samples were rapidly transferred to air tight aluminum boxes. The fresh weight of soil was determined immediately in the laboratory. The samples were kept in an Electric oven for complete drying at a temperature of 105^{o}C for 24 hours.

The percentage of moisture was worked out with the help of the following formula:

$$\text{Moisture (\%)} = \frac{Fresh\ weight\ of\ soil - Oven\ dry\ weight\ of\ soil}{Oven\ dry\ weight\ of\ soil}\ x\ 100$$

Soil moisture percentage was determined on gravimetric basis and the converted in terms of depth of moisture in cm (volumetric basis) using the following formula:

$$Depth\ of\ moisture\ (cm) = \frac{M\ x\ B.D.\ x\ D}{100}$$

where,

M =moisture percentage of soil
B.D. =bulk density (Mg/m^{3})
D = soil depth (cm)

Consumptive use of Moisture

Subsequently after summation of water use from different layers in different periods, the total moisture use was worked out by employing the equation **(Mishra and Ahmed, 1987):**

$$CU = \sum_{Wd\ i-1}^{n} -\frac{M1i - M2i}{100} Asi.Di + E + GWC$$

where,

CU = moisture use from the root zone between two successive sampling periods (mm),
n= number of soil layers sampled in the root zone depth
M1i = soil moisture percentage by weight at the time of first sampling in the ith layer,
M2i = soil moisture percentage by weight at the time of second sampling in the ith layer,
Asi = apparent specific gravity of the ith layer of the soil,
Di = depth of thickness of the ith layer of the soil (mm),
ER = effective rainfall during the period (mm),
GWC= ground water contribution, if any, during the interval (mm),
Wd = drainage for root zone sampled (mm)

WATER USE EFFICIENCY (WUE):
The WUE in terms of production of grain/unit of water consumptively used in each treatment was estimated by using the equation **(Viets, 1962).**

WUE = Y/ET
where,

WUE = water use efficiency (kg grain/ha/mm of water)
Y = grain yield (kg/ha)
ET = evapo-transpiration or total consumptive use (mm)

Effective Rainfall
ER is that fraction of total rainfall available for consumptive use of the crop. ER was computed by soil moisture changes method. Water in the root zone is measured by gravimetric method before and after every rain. Increase in soil moisture and actual evapo-transpiration loss from rain starts till the soil is sampled, is the amount of ER. After heavy rain, evapo- transpiration can be assumed to be at the potential rate during the short period from cessation of rain to sampling time. This can be taken as 0.8 times the evaporation value from USWB Class A Pan.

ER = (M2 - M1) + Kc × PET

where,

ER = effective rainfall (mm)
M1 and M2 = moisture content in root zone and after rain (mm)
Kc= crop coefficient
PET= potential evapo-transpiration (mm)

Splash on Every Successive Rain Storm
For studying splash loss, cylindrical cups of 10 x 20 cm dimension were fixed in one replication in all treatments during the rainy season by digging the pits in such a way that their

edge was 3 cm above the soil surface to prevent the entry of runoff surface flow. The soil splashed by the impact of rain drops was collected after each storm at 8 AM from each plot in properly labelled plastic containers and analysed in the laboratory. The soil was separated for all treatments by filtering the suspension of splashed material through funnel using filter paper. The soil on the filter paper was oven dried for 24 hours at 105oC and weighed. The amount of splashed soil was then calculated in t / ha by the formula given below:

$$Splash\ loss\ (t\ /\ ha) = \frac{3\ (\ 10\ x\ SS)}{7.9756}$$

where, SS = splashed soil (g)

Result and Discussion

Plant Population of Sorghum and Greengram

The results reveal that sorghum stand was significantly highest in sole stand and lowest in sorghum + greengram (2:1 row ratio) at both stages of complete germination and maturity Table 1. Final plant stand was recorded lesser at maturity than initial stage of complete germination. Effect of FYM doses was not found significant on initial and final plant stand of sorghum. The interaction effect of cropping systems and doses of FYM (C × D) on plant stand was non-significant.Doses of FYM did not affect the sorghum stand. Thus, uniformity in plant stand provided equal opportunity to every treatment for expressing its full potential regarding growth, development and productivity of crop. Similar result was obtained by(Langat *et al*., 2006),(Egbe, 2010). However sole greengram crop recorded significantly maximum plant stand of 222.66 thousand/ha at initial stage and 217.55 thousand/ ha at final stage of maturity Table 1. These stands reduced by 147.00 and 167.11 thousand/ha in case of initial stand and by 145.03 and 164.89 thousand/ha in case of final stand under sorghum + greengramintercroppings in 2:1 and 3:1 row ratios, respectively. Effect of FYM doses was not found significant on plant stand of greengram at either stage of observation. However, numerically without FYM treatment maintained considerable lower plant stand than 10 and 20 t FYM/ha plots particularly at final stage of crop maturity. The interaction effect of cropping systems and doses of FYM (C × D) on plant stand was non-significant.Doses of FYM could not affect plant stand of greengram significantly, However without FYM plot maintain lower plant stand numerically compared to application of FYM plots. It might be due to mortality of plants perhaps because of improper management of plant nutrients in without fertilized plot (Rao *et.al*., 2009), (Sharma *et al*.,2012).

Plant height of Sorghumand greengram

In general, plant height (cm) of sorghum increased with each advancement in age up to maturity stage of crop Table 2. However, maximum increase was observed between 30 and 60 DAS irrespective of treatments. Plant height of sorghum recorded at 30 DAS did not exhibit significant variation. Amongst different cropping systems, plant height at 60, 90 DAS and at maturity time showed significant variation, where intercropping system of sorghum + greengram in 2:1 row ratio exhibited tallest plants at all the growth stages of sorghum. The data clearly indicate that doses of FYM caused significant variation in terms of plant height of sorghum at all the stages of plant growth except at 30 DAS and recorded the tallest plants with 20 t/ha but variation observed in between application of 10 and 20 t/ha was not found significant at 60, 90 DAS and at maturity stages. Interaction effects in respect of plant height at all the growth stages were not found significant.It might be due to beneficial effect of greengram intercrop on sorghum through increased nitrogen availability and reduced sorghum competition with component greengram crop for resource utilization particularly the space and solar radiation. Similar results have also been reported by Singh and Jadhav (2003) and Kumar (2012). The higher plant height with increasing FYM application might be due to increase in the availability of nutrients and good physical condition of soil. Gawai and Pawar (2006) also reported that application of 75% RDF (120:60: 60 NPK kg/ha) + FYM @ 5 t/ha + bio-fertilizer gave significantly higher plant height of sorghum as compared to control. (Bhat *et al.*, 2013) also observed that application of FYM @ 30 t / ha recorded maximum plant height of maize as compared to other FYM levels. Where plant height of greengram was not influenced significantly by treatment effects at initial stage of 30 DAS but at maturity stage, treatment effects were significant Table 2. At maturity, intercropped greengram in 3:1 row ratio attained highest plant height (63.1 cm) followed by intercropping in 2:1 row ratio and sole greengram. At final stage of crop maturity, intercropped greengram in 2:1 and 3:1 row ratios increased plant height over sole greengram by margins of 6.1 and 10.6 cm, respectively. Application of FYM @ 20 t/ha treatment proved to be significantly taller plants at maturity time. Interaction effects of cropping systems and doses of FYM on plant height of greengram at different growth stages were found non-significant.It might be due to increased competition for space, light, water and nutrients within greengram plants in intercropping system, which promotes taller plants as compared to sole greengram. These results are similar with the findings of (Kumar, 2012) and (Layek*et al.*, 2012). Application of FYM @ 20 t/ha treatment proved to be significantly taller plants (62.5 cm) at maturity time. Since, plant nutrients are responsible to induce plant height, thus, the crop extracted considerable amount of applied nutrients produced by FYM which resulted in higher plant height. These results are similar with the findings of (Marimuthu*et al.*, 2003) and (Puri and Tiwari, 2008).

Flowering and maturity of sorghum and greengram crop

Sorghum crop took the maximum period to initiate flowering and attain maturity of the crop with intercropped sorghum plots and minimum period under sole sorghum plot Table 3. The results indicate that an increasing levels of FYM markedly enhanced days to flowering and maturity of sorghum crop. Application of 20 t / ha being at par with 10 t / ha, caused considerably delay in both days to flowering and maturity of the crop. Interaction effects in respect of days to flowering and maturity stages were found not significant.These parameters advanced in sole sorghum than intercropping plots. It is the general phenomena that stress conditions influenced earliness in flowering and maturity of the crops. Similar trend have also been reported by (Kanaujia, 2010).An increasing levels of FYM markedly enhanced days to flowering and maturity of sorghum crop. Application of 20 t/ha being at par with 10 t/ha, caused delay in both days to flowering and maturity of sorghum crop. Delay flowering and maturity of sorghum crop might be due to enhanced vegetative growth developed under application of FYM @ 20 t/ha

(Bhat *et al*., 2013).However the results reveal that different cropping systems were found to differ significantly on days to flowering and maturity of greengram crop Table 3. Greengram took maximum period to initiate flowering and attain maturity of crop with sorghum + greengram (3:1 row ratio) followed by sorghum+greengram (2:1 row ratio) and minimum period under sole greengram treatment. The results indicate that an increasing levels of FYM markedly enhanced days to flowering and maturity of greengram crop. Application of 20 t/ha being at par with 10 t/ha, caused considerably delay in both days to flowering and maturity of the crop. Cropping systems × doses of FYM (C × D) interaction was non-significant.The delay in flowering and maturity might be attributed to taller plants of greengram in intercropping plants because of sorghum shading effect and other adverse effect on greengram. Application of FYM @ 20 t/ha delayed flowering and maturity of greengram crop over without FYM treatment. Higher vegetative growth recorded with 20 t/ha might have been responsible to utilize higher days to attain flowering and maturity of the crop(Marimuthu*et al*., 2003), (Sharma *et al*.,2012).

Soil moisture content of sorghum and greengram crop as a sole and intercrop

The data reveal that soil moisture content up to one metre depth at different stages of plant growth appeared remarkable variation as affected by cropping systems Table 4. The maximum soil moisture content was recorded at 30, 60 and 90 DAS under sole greengram. Moreover, the soil moisture content under intercropping system of sorghum + greengram in 2:1 and 3:1 row ratios showed almost similar pattern with slight variation but after harvest of greengram crop, higher soil moisture was noticed under sorghum + greengram (2:1 row ratio) followed by sorghum + greengram (3:1 row ratio) and lower under sole sorghum cropping system. The soil moisture being observed up to one metre depth tended to decrease with increasing levels of FYM at almost all the plant growth stages. The lowest soil moisture was observed with high dose of FYM *i.e*. 20 t/ha while highest under control plot (without FYM) at all the stages of plant growth.Proper crop cover and low water requirement of greengram crop reduced loss, thus left more moisture in soil. Contrary to it more moisture loss through evaporation in absence of proper canopy cover and higher water requirement of sorghum crop might has left minimum moisture in soil. Better moisture conservation in sole greengram plot has also been reported by Prasad *et al*. (2003).Lower soil moisture was observed with application of FYM @ 20 t/ha as compared to 10 t/ha and control plots at all the stages of plant growth. More available nutrients promote plant growth and concomitantly the crop canopy and this might have in twin increased transpiration loss resulting in lower soil moisture content under 20 t FYM/ha treatment (Tanwar*et al*. 2014).

Consumptive use (mm per metre soil depth)

The data indicate that sole sorghum exerted the maximum moisture use closely followed by sorghum + greengram (3:1 row ratio) and the minimum under sole greengram but after harvest of greengram crop, higher soil moisture extraction was noticed under sole sorghum treatment at all the stages of crop growth Table 5.The utilization of soil moisture by the crops increased remarkably with increasing levels of FYM at all the crop growth stages. The maximum values were recorded with 20 t/ha, while minimum under no fertilized plot (control) at almost all the stages of crop growth. Similar result was reported by (Devi *et al*., 2014), (Om *et al*., 2016).

Total water use, Water use efficiency, Splash loss

The data reveal that the maximum total water use was recorded under sole sorghum being 397.1 mm followed by intercropping system of sorghum + greengram in 3:1 row ratio being 354.7 mm and the minimum under sole greengram being 300.7 mm. Total water use increased with increasing levels of FYM Table 6. The highest total water use was recorded with application of 20 t/ha being 355.8 mm while the lowest under control plot (346.3 mm).However the data clearly indicate that highest WUE was observed under intercropping system of sorghum + greengram in 2:1 row ratio being 8.17 kg grain/ha/mm of water followed by sole greengram being8.12 kg grain/ha/mm of water and the lowest under sole sorghum being 6.29 kg grain/ha/mm of water.The WUE increased with increasing levels of FYM. The highest value was recorded with the application of 20 t/ha being 8.31 kg grain/ha/mm of water. The per cent increase in WUE due to application of 20 t FYM/ha over 10 t/ha and control was 5.32 and 32.32, respectively.Total water use and water use efficiency were found to be higher under application of FYM @ 20 t/ha in comparison to 10 t/ha and control treatments. It is an established fact that higher level of production as a result of optimum for fertilization can improve the rates of yield to consumptive water use leading to an efficient utilization of moisture with 20 t FYM/ha than other treatments. These results are substantiated by the findings of Sharma and Guled (2011).Data presented in Table 6 reveal that different cropping systems marked variation for splash loss of soil. Minimum splash loss of 2.94 t/ha was observed under sole greengram plot and maximum of 4.80 t/ha under sole sorghum plot. Splash loss during course of investigation, different cropping systems may be categorized as given below :Sole sorghum > sorghum + greengram (3:1 row ratio) > sorghum + greengram (2:1 row ratio) > sole Greengram In case of FYM doses, maximum splash loss of 4.40 t/ha was recorded under without FYM plot followed by 10 t FYM/ha application (3.98 t/ha). Application of FYM @ 20 t/ha resulted minimum splash loss of soil (3.80 t/ha).It was due to the reason that cover crop of greengram produced more crop canopy and thereby reduced splash loss to the minimum. Maximum splash loss in sole sorghum plot seems due to least canopy development where rain strokes on soil caused maximum soil erosion. In intercropping system of sorghum + greengram in 2:1 row ratio showed lesser splash loss than 3:1 row ratio because higher population of intercrop which covered most of the area by canopy development. These results confirm the findings of (Prasad *et al*. 2003), (Kanaujia, 2010) and (Kumar, 2012).Higher splash loss occurred under without FYM plot in comparison to application of FYM treatments. The soil loss was found to be directly governed by crop canopy development. Since, higher canopy was found in fertilized plots resulting soil loss was less. (Ghosh*et al.*, 2012) also reported that the integrated use of organic input management showed significant impact on reduction of runoff and soil loss.

Table-1. Effect of Sorghum-based intercropping system on Sorghum and greengram plant population

Treatments	Sorghum		green gram	
	Initial plant stand (000 / ha) after thinning	Final plant stand (000 / ha) at maturity	Initial plant stand (000 / ha)	Final plant stand (000 / ha) at maturity
Cropping systems				

Sole sorghum/ Sole green gram	112.11	108.74	222.66	217.55
Sorghum+ greengram (2:1)	74.55	73.21	75.66	72.52
Sorghum+ greengram (3:1)	84.11	82.30	55.55	52.66
SE(d)	3.31	2.84	6.16	4.69
CD (P=0.05)	7.02	6.03	13.06	9.95
Doses of FYM				
Without FYM	90.66	87.30	118.44	113.63
10 t / ha	89.99	88.06	117.44	114.11
20 t / ha	90.11	88.90	117.99	115.00
SE (d)	3.31	2.84	6.16	4.69
CD (P=0.05)	NS	NS	NS	NS
C x D				
SE (d)	**5.74**	**4.92**	**10.67**	**8.13**
CD (P=0.05)	**NS**	**NS**	**NS**	**NS**

Table-2.Effect of Sorghum-based intercropping system on Sorghum and Greengram plant height

Treatment	**Plant height (cm) Sorghum**				**Plant height (cm) greengram**	
	30 DAS	**60 DAS**	**90 DAS**	**Atmaturity**	**30 DAS**	**At maturity**
Cropping systems						
Sole sorghum/Sole greengram	29.6	94.5	152.1	167.5	27.7	52.5
Sorghum+greengram (2:1)	30.8	103.7	163.1	180.2	28.2	58.6
Sorghum+ greengram (3:1)	30.3	99.8	159.5	175.0	28.6	63.1
SE(d)	**0.97**	**2.02**	**3.97**	**4.52**	**0.81**	**1.35**
CD (P = 0.05)	**NS**	**4.29**	**8.42**	**9.59**	**NS**	**2.86**
Doses of FYM						
Without FYM	29.1	89.4	142.6	153.0	27.2	52.3
10 t / ha	30.5	102.6	164.1	182.0	28.4	59.5
20 t / ha	31.0	106.0	167.9	187.7	28.9	62.5
SE (d)	**0.97**	**2.02**	**3.97**	**4.52**	**0.81**	**1.35**
CD (P = 0.05)	**NS**	**4.29**	**8.42**	**9.59**	**NS**	**2.86**

Table- 3 Effect of Sorghum-based intercropping system to days to flowering and maturity of sorghum and greengram crop

Treatments	sorghum		greengram	
	Days to flowering	Days to maturity	Days to flowering	Days to maturity
Cropping systems				
Sole sorghum/Sole greengram	89.5	119.5	36.8	58.6
Sorghum+ greengram (2:1)	92.8	123.8	38.4	59.6
Sorghum+ greengram (3:1)	91.6	122.7	38.8	60.5
SE (d)	**0.86**	**1.49**	**0.73**	**0.58**
CD (P=0.05)	**1.82**	**3.16**	**1.55**	**1.22**
Doses of FYM				
Without FYM	88.7	118.7	36.4	58.0
10 t / ha	92.1	123.0	38.5	60.2
20 t / ha	93.0	124.0	39.1	60.6
SE (d)	0.86	1.49	0.73	0.58
CD (P=0.05)	1.82	3.16	1.55	1.22
C x D				
SE (d)	**1.49**	**2.58**	**1.27**	**1.00**
CD (P=0.05)	**NS**	**NS**	**NS**	**NS**

Table-4 Effect of Sorghum-based intercropping system on soil moisture content of sorghum and greengram crop

Treatment	Soil moisture content up to one metre depth(mm)				
	Sowingtime	**30 DAS**	**60 DAS**	**90 DAS**	**Atharvest**
Cropping systems					
Sole sorghum	280.8	262.4	171.0	138.8	98.8
Sole greengram	280.8	264.6	185.8	195.2	-
Sorghum + greengram (2:1)	280.8	264.2	184.5	169.3	142.5
Sorghum + greengram (3:1)	280.8	263.9	184.1	168.7	141.2
Doses of FYM					
Without FYM	280.8	264.4	183.0	172.3	131.0
10 t / ha	280.8	263.7	181.1	167.2	126.9
20 t / ha	280.8	263.2	180.0	164.4	124.5

Table-5Effect of Sorghum-based intercropping system on Consumptive use (mm per metre soil depth)of sorghum and greengram

Treatment	Consumptive use (mm per metre soil depth)			
	Sowing time to 30DAS	30 DAS to 60 DAS	60 DAS to 90 DAS	90 DAS to at harvest
Cropping systems				
Sole sorghum	144.4	152.5	60.3	39.9
Sole greengram	142.2	139.8	18.7	-
Sorghum + greengram (2:1)	142.6	140.7	43.3	26.8
Sorghum + greengram (3:1)	142.9	140.7	43.6	27.5
Doses of FYM				
Without FYM	142.4	142.3	38.9	22.7
10 t / ha	143.1	143.6	41.9	23.7
20 t / ha	143.5	144.3	43.6	24.4

Table- 6 Effect of Sorghum-based intercropping system on total water use, water use efficiency, splash loss in Sorghum and greengram crop.

Treatments	total water use (mm)	water use efficiency (kg grain/ha/mm of water)	splash loss (t/ha)
Cropping systems			
Sole sorghum	397.1	6.29	4.80
Sole greengram	300.7	8.12	2.94
Sorghum+ greengram (2:1)	353.4	8.17	4.17
Sorghum+ greengram (3:1)	354.7	7.39	4.33
SE (d)	--	--	--
CD (P=0.05)	--	--	--
Doses of FYM			
Without FYM	346.3	6.28	4.40
10 t / ha	352.3	7.89	3.98
20 t / ha	355.8	8.31	3.80
SE (d)	--	--	--
CD (P=0.05)	--	--	--

C x D			
SE (d)	--	--	--
CD (P=0.05)	--	--	--

Conclusion

On the basis of results obtained during course of investigation, it may be inferred that growth of greengram in terms of sorghum equivalent growth and yield showed highest significant production in row crop adjustment of sorghum + greengram (2:1 row ratio). Moreover, land equivalent ratio, water use efficiency and net return were also highest found to be the remunerative, may be recommended for adoption by cultivators of rainfed areas for boosting the crop production. Application of FYM @ 10 t/ha gave best performance in respect of vegetative growth, yield on sandy loam soil under rainfed condition in central India.

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Comment [RM2]: Add references limited 5 years ago

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