Response organic fertilizers on Sorghum: Greengram intercropping on yield attribute, yield, and economics at varying row ratios under rainfed situations

Abstract

India is the largest producer of Pulses, however productivity is stills very low, and need of millet is also increasing day by day in this concern to utilize the filed efficiently to get higher millet yield as well as pulses per unit area. 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 of different row ratio and doses of farm yard manure (FYM) on, yield 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 Factorial 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 significantly ($p < 0.05$) variation, whereas sorghum + greengram (2:1 row ratio) brought out significantly ($p < 0.05$) the highest production as compared to other cropping systems. Moreover, the land equivalent ratio, gross return and net return were also found to be the highest. Simultaneously Increasing rates of FYM brought out significant ($p < 0.05$) 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.

Keywords: intercropping system, sorghum, greengram, yield, economics

1. Introduction

Rain-fed agriculture makes sure there is enough food for everyone in the world because it accounts for 80% of all cultivation. These areas are under danger due to poverty, starvation, a lack of water, soil degradation, and inadequate physical and social infrastructure. Crop yield in rainfed locations is nevertheless constrained by low soil nitrogen retention and low fertiliser use (Pasuquin *et al.*, 2014). Crop management strategies that effectively employ soil nutrients and use moderate nutrient inputs while lowering risk are necessary for stabilising and growing crop yield in these settings (Chikowo *et al.*, 2014). Integrated nutrient management raises the fertility, productivity, water usage effectiveness, and physical, chemical, and biological qualities of rainfed soil (Pandey *et al.*, 2003). The availability of rainwater, dry and rainy periods, and water excess and deficiency all affect crop planning (Martorano *et al.*, 2017). Cropping pattern is the proportion of land that is being used for various crops at a particular period (Akhtar & Acharya 2015). On the same plot of land, intercropping entails planting two or more crops in rows. Intercropping strives to boost output stability and productivity per unit area. Due to runoff water washing nutrients away and crop use of organic manures and fertilisers, soils nourished by rain are critically low in fertility. The problem is expected to continue because of a lack of fertilizer (Chianu *et al.*, 2012). Legumes and organic manures must be prioritised in cropping systems. Indian water resources will be strained by climate change. Water demand, supply, and quality are impacted by the climate. Climate change will exacerbate competition for water consumption for economic, social, and environmental reasons in dry and semi-arid regions. Uneven distribution of water resources exists in both space and time (Mall *et al.*, 2007). A staple crop grown all throughout the world is sorghum (*Sorghum bicolor* L.) (Dahlberg *et al.*, 2011). For many people in Asia and Africa, sorghum is a staple food. Millions of animals that provide food for humans are also fed by it (Hariprasanna & Rakshit 2016). Sorghum grain can take the place of other grains in the diets of dairy, poultry, and swine animals since it contains 10.4% protein, 1.9% fat, 72.6% carbs, and 1.6% mineral content. It serves as a raw resource for industries in the US and other affluent countries (Ratnavathi & Komala, 2016). The products sold include bakery items such buns, bread, cakes, cookies, and biscuits as well as portable and gasoline alcohol. Drought resilience is sorghum's strongest quality Wanjuu, 2017). India has the biggest sorghum acreage but, after the US, the second-highest production (Johnson *et al.*, 2013). Greengram is the third-most significant legume crop in India. Greengram enhances soil fertility in India by fixing atmospheric nitrogen. It is a little herbaceous annual intercrop that can withstand drought and is grown in dryland farming. Being a short-duration (60-65 day) crop with wild adaptability that is produced both as a cereal intercrop and as a standalone crop all over the world. According to Budher and Tamilselvan (2003) and Dar *et al*., (2003) sorghum and greengram intercropping was more effective in retaining soil moisture, producing more, and being more lucrative than sorghum and greengram alone. The additive and replacement series in intercropping systems are dependent on the percentage of plant stand utilized for each crop. The additive series, which is most common in India, sows the base crop with 100% of the recommended stand (Layek, *et al*., 2012). By modifying crop geometry, intercrop is added to the base crop. Intercrop is lower than its one and only stands recommendation. Component crops are replacement series crops. For the introduction of another element, one is sacrificed. Intercropping increases agricultural output, profitability, and land use efficiency. Solar energy and crop association benefits are maximized by intercropping. These advantages are typically stronger in areas with extensive crop and stress. It breaks down to dissolve soil minerals and provides food for soil bacteria (Sharma and Guled, 2011). FYM enhances water permeability and soil granulation while also increasing water retaining capacity. The following study, "Sorghum - based intercropping system as influenced by organic manuring under rainfed condition," was conducted during the 2017 *kharif* season at the Soil Conservation and Water Management Farm of C. S. Azad University of Agriculture and Technology, Kanpur, with the following goals: To study the growth and yield behavior of various row crops.

2. Material and method

2.1 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 25^{o} 26' and 26^{o} 58' North latitude and 79^{o} 31' and 80^{o} 34' East longitude.

2.2 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 ^{o}C while January is coldest when night temperature falls to 4 ^{o}C. The weather parameters prevailed during experimental crop period was collected from "Meteorological Observatory of the University".

2.3 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, Wilting point (%) 6.2, PH 7.8, Electrical conductivity (dS m^{-1} at 25 ^{o}C) 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).

2.4 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.

2.5 Yield attributes and yield:
Observation on Number of pods per plant, Length of panicle, Number of grains/seeds per panicle/pod, 1000-grain/seed weight Yield of crops: Grain/seed yield, Stover yield as the standard procedure.

2.6 Sorghum equivalent grain yield (SEGY):

It was worked out by using the following formula suggested **by Lal and Ray (1976).**

$$SEGY\ (q/ha) = \frac{Seed\ yield\ of\ greengram(q/ha)\ x\ \ Seed\ price\ of\ greengram(Rs/q) +\ Grain\ yield\ of\ sorghum\ (q/ha)}{Grain\ price\ of\ sorghum\ (Rs/q)}$$

2.7 Land equivalent ratio (LER):

LER is the relative land area under sole crops that is required to produce the yield achieved in intercropping. In the present experiment, the LER was estimated by following equation **(Willey, 1979).**

$$LER = \frac{Yield\ of\ sorghum\ in\ intercropping}{Yield\ of\ sorghum\ in\ sole\ cropping} + \frac{Yield\ of\ greengram\ in\ intercropping}{Yield\ of\ greengram\ in\ sole\ cropping}$$

2.8 Economics:

It was computed in terms of total cost of cultivation, gross return and net return for different treatments. As per the standard procedure.

3. Result and Discussion

3.1 Yield and Yield Attribute of Sorghum and greengram:

Sorghum
Data presented in Table 1 shows that intercropped sorghum in both row ratios being at par with each other recorded significantly ($p < 0.05$) more length of panicle, number of grains/panicle and 1000-grain weight than sole sorghum. However, these yield attributes were found significantly ($p < 0.05$) highest in intercropped sorghum under 2:1 row ratio followed by 3:1 row ratio and lowest were recorded in sole sorghum. The intercropped sorghum in 2:1 row ratio 0.79 and 5.13 % higher number of grains/panicle, 4.81 and 21.74 % higher length of panicle and 5.62 and 14.02 % higher 1000-grain weight over intercropped sorghum in 3:1 row ratio and sole sorghum, respectively. The reason may be explained that sorghum in intercropping system might has benefited by symbiotic N fixation in greengram intercrop which resulted in better growth and improved yield attributes of sorghum. Tripathi *et al*. (2010) also reported that intercropping treatments recorded higher values of yield attributes as compared to sole maize crop. Further with an increasing doses of FYM significantly ($p < 0.05$) enhanced yield attributes and maximized it with 20 t/ha. However, variation in yield attributes being recorded in 10 and 20 t FYM/ha were not found significant. The per cent increase in number of grains/panicle due to 20 t/ha over 10 t/ha and control was 1.75 and 14.15, respectively. Interaction effects were found non-significant on yield attributes of sorghum. FYM proved to have marked superiority in terms of yield attributes of sorghum over without FYM treatment. Increase in yield parameters by FYM might be due to good source of plant nutrients. It provides food for soil micro-organisms and by-products of decomposition help to bring the mineral constituents of soil into solution which helps to increase plant growth and root development could be ascribed to a better translocation of photosynthate towards the yield attributes.

Favorable effects of FYM on yield attributes of sorghum have also been reported by Yadav *et al*. (2012). The results reveal that stover yield of sorghum/unit was recorded highest of 7310 kg/ha in sole sorghum. It was found 1100 and 1330 kg/ha or 17.71 and 22.24% higher than the stover yield obtained under 3:1 and 2:1 row ratios of intercropped sorghum, respectively.

It is attributed mainly to sorghum population per unit area as 75 and 67% was maintained under 3:1 and 2:1 intercropping systems against 100 % in sole sorghum, respectively. These results are in accordance to the findings of Budher and Tamilselvan (2003). However with increasing doses of FYM markedly enhanced stover yield which maximized it with 20 t/ha. However, marked variation in stover yield being observed in between 10 and 20 t/ha did not find the level of significance. On mean basis, the increase in stover yield due to 20 t/ha over 10 t/ha and control was 2.81 and 20.62%, respectively. An increasing doses of FYM markedly enhanced stover yield of sorghum which maximized it with 20 t/ha. Improvement in stover yield of sorghum crop on application of 20 t/ha could be ascribed to profound influence of nutrients on plant growth, causing increase in nutrients accumulation and their translocation towards the stover yield formation. These results are in conformity with the findings of Patidar and Mali (2001), Yadav *et al*. (2012) and Jadhao *et al*. (2015).

Greengram

Data reveal that sole greengram have been found to reflect the significantly ($p < 0.05$) higher number of pods/plant, compared to other cropping systems Table 1. The lowest number of pods/plant has been noticed under sorghum + greengram (3:1) treatment. Sole greengram cropping brought out 25.38 and 55.77 % higher number of pods/plant over sorghum + greengram (2:1 row ratio) and sorghum + greengram (3:1 row ratio), respectively. An increasing levels of FYM significantly ($p < 0.05$) enhanced number of pods/plant and maximized it with 20 t/ha. However, variation in number of pods/plant being recorded in between 10 and 20 t/ha was not found significant. The per cent increase in number of pods/plant due to 20 t/ha over 10 t/ha and control was 8.04 and 52.22, respectively. Interaction between cropping systems and doses of FYM was non-significant. Further it is indicate significant ($p < 0.05$) variation in respect of number of seeds/pod of greengram. Sole greengram plot brought out significantly ($p < 0.05$) highest number of seeds/ pod being 9.2, whereas intercropping system of sorghum + greengram in 2:1 row ratio proved to be under intermediate group being 8.5 while the lowest under sorghum + greengram (3:1 row ratio). The maximum value of 9.3 was observed under FYM level with 20 t/ha while the minimum of 7.6 under without fertilized plot. The increase in number of seeds/pod due to application of 20 t FYM/ha over control were 22.37 and 15.79 %, respectively. Interaction between cropping systems and doses of FYM (C × D) was non-significant. The data reveal that the cropping systems and doses of FYM had non-significant effect on 1000-seed weight (g) of greengram. However, 1000-seed weight was recorded higher in sole greengram and lower under sorghum + greengram (3:1 row ratio) treatment. 1000-seed weight was recorded higher with FYM @ 20 t/ ha and lower with control plot. Further data reveal that sole greengram cropping has been found to reflect the maximum stover yield as compared to other cropping systems. Intercropping system of sorghum + greengram in 2:1 row ratio exhibited significantly ($p < 0.05$) higher stover yield than sorghum + greengram (3:1 row ratio) intercropped treatment. Results indicate that an increasing doses of FYM markedly enhanced stover yield which maximized it with 20 t/ha. However, marked variation in stover yield being observed in between 10 and 20 t/ha did not find the level of significance. Increase in stover yield due to 20 t/ha over 10 t/ha and control was 7.77 and 46.05 %, respectively. Interaction effect was non-significant. Significant ($p < 0.05$) improvement in yield parameters and stover yield with sole greengram crop indicate better tanslocation of photosynthates to the reproductive organs contributing yields. On the contrary, greengram grown under intercropped led to adverse effect of shading due to sorghum crop particularly during the reproductive period which might have affected the accumulation and translocation of photosynthates to organs. These findings are corroborated with the results of Verma *et al*. (2005) and Kanaujia (2010). The marked improvement in number of pods/plant and stover yield with application of FYM treatment over without FYM plot might be attributed to considerably more lateral roots expanded in soil made it possible to extract the higher available moisture and encouraged vegetative and reproductive phases which assimilating of more food materials by accelerating the photosynthetic process resulting in higher growth as well as yield attributes and ultimately higher stover yield of greengram. Favourable effects of FYM on yield attributes and stover yield of greengram have also been reported by Marimuthu *et al.* (2003), Kedar *et al.* (2004), Singh *et al*. (2005 a) and Saravanan and Kumar (2013).

3.2 Sorghum equivalent grain yield and LER:

The results reveal that cropping systems showed significantly ($p < 0.05$)variation on sorghum equivalent grain yield Table 2. Intercropping of sorghum + greengram in 2:1 row ratio resulted significantly ($p < 0.05$) higher sorghum equivalent grain yield over other cropping systems. Other three cropping systems recorded equivalent yield at par with each other being numerically higher yield in sorghum + greengram (3:1 row ratio) intercropping treatment. The highest productive system of sorghum + greengram in 2:1 row ratio recorded 2660, 3860 and 4370 kg/ha or 10.14, 15.43 and 17.83 % higher sorghum equivalent grain yield than the systems of sorghum + greengram in 3:1 row ratio, sole sorghum and sole greengram, respectively. It might be attributed to increase in intercropped sorghum yield in proportion to plant stand of sorghum in intercropping systems. Sole greengram could yield at par with intercropping in 3:1 row ratio because of higher price of greengram seed produce. Sorghum equivalent grain yield in sole sorghum could not compensate with other cropping systems mainly due to much lower price of sorghum grain produce. These findings are in accordance with the results of Budher and Tamilselvan (2003), Rathore *et al.* (2012) and Panahale *et al.* (2014). It is evident from the perusal of data that sorghum equivalent grain yield increased remarkably with increase in levels of FYM and yield being maximized at 20 t/ha. However, variation in grain yield being observed in between 10 and 20 t/ha could not touch the line of significance. On an average, 20 t/ha enhanced grain yield over 10 t/ ha and control (without FYM) by 6.39 and 35.12 per cent, respectively. The effect of cropping systems × doses of FYM was not found significant. Sorghum equivalent grain yield increased remarkably with increase in levels of FYM and yield being maximized at 20 t/ha. However, variation in grain yield being observed in between 10 and 20 t/ha could not touch the line of significance may be due to most efficient utilization of available moisture and nutrients at this dose. All growth characters along with yield parameters were found most viable and effective in encouraging yield at high dose of FYM. These results are in line with the findings of Reddy *et al.* (2011), Yadav *et al.* (2012) and Saravanan and Kumar (2013).

3.3 Land equivalent ratio:

All groups of intercropping systems produced more LER over sole croppings Table 2. Intercropping systems of sorghum + greengram in 2:1 and 3:1 row ratios attained 1.15 and 1.05 LER values, respectively being significantly ($p < 0.05$) different from each other. It might be attributed to increased sorghum yield in intercropping systems over sole sorghum in proportion to plant population of sorghum maintained/unit area in sole and intercropping systems. Almost similar results were reported by Sheoran *et al*., (2010) and Kumar (2012). Results indicate that an increasing doses of FYM markedly enhanced LER which maximized it with 20 t/ha. However, marked variation in LER being observed in 10 and 20 t FYM/ha did not find the level of significance. Interaction effect was not found significantly ($p < 0.05$)on LER. Application of 20 t/ha proved to be marked superior over without FYM plot. It might be due to attributed to increased seed yield in higher proportion to stover yield with 20 t FYM/ha treatment over without FYM plot. Finding supports with Yadav *et al*. (2012).

3.4 Economics:

Data reveal that maximum cost of cultivation was observed with sole sorghum (Rs 35537/ha) Table 3. The highest gross return (Rs 61528/ha) and net return (Rs 26885/ha) were observed with intercropping system of sorghum + greengram in 2:1 row ratio followed by sorghum + greengram (3:1 row ratio) while the lowest under sole greengram plot. Findings reveal that cost of cultivation increased with increasing levels of FYM and the maximum value being (Rs 38875/ ha) observed with 20 t/ha. Gross return also showed similar pattern. The highest gross return being observed with 20 t/ha which was Rs 61241/ha followed by 10 t/ha (Rs 57881/ha) while the lowest gross return by recording Rs 46120/ha under control plot. The highest net return recording by Rs 22376/ha was calculated with 10 t/ha followed by 20 t/ha (Rs 22366/ha) while the lowest recording under control plot (Rs 15745/ha). These might be attributed to higher sorghum equivalent grain yield as there was not much variation in cost of cultivation under intercropping systems. In sole cropping, both crops gave gross income at par with each other but net return was higher in sole sorghum than sole greengram crop. The reason may be explained that lesser straw yield of greengram than sorghum reduced gross income marginally. These results are in agreement to the findings of Budher and Tamilselvan (2003). Cost of cultivation and gross return increased with increasing levels of FYM and the maximum values being observed with 20 t/ ha. It might be ascribed to optimum utilization of fertilizer for seed and stover yield up to this level. Though, the cost of cultivation was increased with increasing levels of fertilizer but the rate of increase in yield was comparatively much higher which ultimately resulted in higher gross return and net return. These results are similar with the findings of Singh *et al.* (2005 b) and Yadav *et al.* (2012).

Table. 1- Effect of organic manure on sorghum-based intercropping system on yield attributes of Sorghum and green gram

Treatments	Yield attribute and yield of Sorgum				Yield attribute and yield of Greengram			
	Length of panicle (cm	Number of grains / panicle	1000-grain weight (g)	Stover yield (kg/ha)	Number of pods / plant	Number of seeds / pod	1000-seed weight (g)	Stover yield (kg/ha)
Cropping systems								
Sole sorghum/Sole greengram	16.1	978.6	21.4	7310	32.6	9.2	33.2	1880
Sorghum+ greengram (2:1)	19.6	1028.8	24.4	5980	26.0	8.5	32.4	6300
Sorghum+ greengram (3:1)	18.7	1020.4	23.1	6210	21.2	8.1	31.9	3800
SE (d)	**0.81**	**19.46**	**0.74**	**193**	**1.07**	**0.16**	**0.66**	**81**
CD (P=0.05)	**1.72**	**41.26**	**1.56**	**409**	**2.26**	**0.34**	**NS**	**173**
Doses of FYM								
Without FYM	16.1	927.8	21.0	5770	20.3	7.6	31.8	1880
10 t / ha	18.6	1040.9	23.5	6770	28.6	8.8	32.7	6300
20 t / ha	19.7	1059.1	24.3	6600	30.9	9.3	33.0	3800
SE (d)	0.81	19.46	0.74	193	1.07	0.16	0.66	81
CD (P=0.05)	1.72	41.26	1.56	409	2.26	0.34	NS	173
C x D								
SE (d)	**1.40**	**33.71**	**1.27**	**334**	**1.85**	**0.28**	**1.15**	**141**
CD (P=0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

Table. 2- Effect of organic manure on sorghum-based intercropping system on sogrhum equivalent yield and LER

Treatments	sorghum equivalent grain yield (kg/ ha)	LER
Cropping systems		
Sole sorghum	2502	1.00
Sole greengram	2451	1.00
Sorghum+ greengram (2:1)	2888	1.15
Sorghum+ greengram (3:1)	2622	1.05
SE (d)	**126**	**0.02**
CD (P=0.05)	**262**	**0.04**
Doses of FYM		
Without FYM	2167	1.02
10 t / ha	2752	1.06
20 t / ha	2928	1.07
SE (d)	**112**	**0.02**
CD (P=0.05)	**233**	**0.03**
C x D		
SE (d)	**224**	**0.03**
CD (P=0.05)	**NS**	**NS**

Table. 3- Effect of organic manure on sorghum-based intercropping system on economics of Sorghum and greengram intercropping

Treatment	Cost of cultivation (Rs/ha)				Gross return (Rs/ha)			Net return (Rs/ha)
	Common	Variable		Total	By grain/seed	By stover/straw	Total	
		Cropping systems	Doses of FYM					
Cropping systems								
Sole sorghum	10570	20420	4543	35537	41277	14620	55897	20360
Sole greengram	10570	19680	4543	39793	40443	5650	46093	11300
Sorghum + greengram (2:1)	10570	19530	4543	34643	47661	13867	61528	26885
Sorghum + greengram (3:1)	10570	19590	4543	34703	43257	13550	56807	22104
Doses of FYM								
Without FYM	10570	19805	-	30375	35758	10362	46120	15745

10 t /ha	10570	19805	5130	35505	45409	12472	57881	22376
20 t / ha	10570	19805	8500	38875	48311	12930	61241	22366

Conclusion

It is possible to draw the following conclusions based on the findings that were acquired throughout the course of the investigation: Row crop adjustments made with sorghum and greengram resulted in the highest significant ($p < 0.05$) output of greengram yield when measured in terms of sorghum equivalent grain yield (2:1 row ratio). In addition, land equivalent ratio and net return were determined to be the most profitable aspects, which suggest that they should be considered by farmers in rainfed areas as potential strategies for increasing crop production. The application of FYM at a rate of 10 tons per hectare offered the greatest results in terms of yield characteristics, yield, and net return on sandy loam soil in rainfed conditions.

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