J. Farm Sci., 36(1): (16-19) 2023

RESEARCH PAPER

System analysis of browntop millet based intercropping system in vertisols under rainfed condition

H. P. DARSHAN[1], CHIDANAD P. MANSUR[1], D. SHIVAMURTHY[1] AND J. K. NEELAKANTH[2]

[1]Department of Agronomy, [2]Department of Agril. Engineering
College of Agriculture,University of Agriculture Sciences, Dharwad - 580 005, Karnataka, India
E-mails: darshanagri10@gmail.com, mansurcp@uasd.in

(Received: November, 2022 ; Accepted: January, 2023)

Abstract: A field experiment was conducted at Main Agricultural Research Station, UAS, Dharwad during *kharif* season, 2021-22 to analyze the browntop millet intercropping system with legumes. The experiment was laid out in randomized complete block design with thirteen treatments and replicated thrice. Among thirteen treatments the browntop millet was intercropped with groundnut, soybean, green gram and black gram in 4:2 and 2:1 row ratio and remaining treatments were individual sole crops. Sole browntop millet was recorded significantly higher grain yield (973.61 ka ha^{-1}), whereas, among the different intercropping systems 4:2 row proportion of browntop millet + groundnut was recorded numerically higher grain yield (674.31 kg ha^{-1}). Significantly higher browntop millet equivalent yield (BMEY) was recorded in sole groundnut (3689 kg ha^{-1}), whereas, among the different intercropping system browntop millet + groundnut (4:2) was recorded numerically higher BMEY (2326 kg ha^{-1}). Browntop millet + black gram at 4:2 row proportion was recorded numerically higher value of land equivalent ratio, area time equivalent ratio and system productivity index (1.192, 1.13 and 1159.49, respecitvely). Browntop millet was shown negative trend with respect to agrressivity. Significantly higher value of relative crowding coefficient was recorded with browntop millet + groundnut with 4:2 row ratio (18.12). Sole groundnut was recorded significantly higher gross returns, net returns and benefit cost ratio (₹ 1,13,438, ₹ 72,934 ha^{-1} and 2.80, respectively). However, among the different intercropping systems browntop millet + groundnut at 4:2 row proportion was recorded numerically higher gross returns, net returns and B:C ratio (₹ 72,397 ha^{-1}, ₹ 37,971 ha^{-1} and 2.10, respectively).

Keywords: Browntop millet, Economics, Intercropping indices, Intercropping system

Introduction

Intercropping has been acknowledged as a highly wide spread practice in the tropics. Greater focus is placed on intercropping system is to mainly because it provides a simple and affordable means to achieve higher yield benefits. In recent times, it has been realized that intercropping is a very common practice and will continue in future also. From numerous studies, it is notified that the yield of the cereal component is typically less affected by component crop densities. The selection of the crop and the manipulation of plant population and row arrangement can result in a financial advantage in intercropping system. These should be selected in such a way that there should be minimum intercrop competition and maximum productivity (Ahuja and Singh, 1987; Ahmad and Prasad, 1996).

Materials and method

The field experiment was conducted on medium deep black soil at Main Agricultural Research Station, UAS, Dharwad (located at 15^{o} 26^{1} N latitude, 75^{o} 07^{1} E longitude and an altitude of 678 m above the mean sea level.). The total rainfall received during 2021 was 1052.30 mm. There were 13 treatments comprising sole and intercropping systems. The experiment was laid out in randomized complete block design and replicated thrice. The land was ploughed twice with tractor drawn mould board plough in order to bring the land to the optimum tilth. The soil of experimental plot was medium deep black soil with pH 7.74, organic carbon 0.49 per cent, available N, P and K were 290.80, 28.30 and 331.40 kg ha^{-1}, respectively.

Sowing of browntop millet and different legumes were done on 26th July 2021. Seeds of browntop millet (Local variety), groundnut (DH-256), soybean (DSb-21), green gram (IPM-2-14) and black gram (DU-1) were sown by using khera method (dropping of seeds through hands in furrow behind the plough) with seed rate of 7 kg ha^{-1} (Browntop millet), 110 kg ha^{-1} (Groundnut), 62 kg ha^{-1} (Soybean), 13 kg ha^{-1} (Green gram), 16 kg ha^{-1} (Black gram). Weeds were controlled through one hoeing at 30 days after sowing and one manual weeding. The recommended dose of fertilizer for browntop millet (30:15:15 kg ha^{-1}), groundnut (18:46:25 kg ha^{-1}), soybean (40:80:25 kg ha^{-1}), green gram (25:50:0 kg ha^{-1}) and black gram (25:50:0 kg ha^{-1}) in the form DAP, urea and MOP was applied at the time of sowing. In case of intercropping treatments fertilizers were applied based on the population level. The seed treatment with *Rhizobium strains* (50 g kg^{-1} seeds) for seeds of groundnut, soybean, green gram and black gram, browntop millet was treated with *Azospirullum* (50 g kg^{-1} seeds). Five plants were tagged randomly from each plot for recording various yield attributes at harvest stage. Standard procedures were used to record the different observations in both main and intercrops. Significance and non-significance difference between treatments was derived through Duncan's Multiple Range Test (DMRT) using Online Statistical Analysis Tools (OPSTAT). The yield was computed for browntop millet equivalent yield (BMEY), land equivalent ratio (LER), area time equivalent ratio (ATER), system productivity index (SPI), gross and net returns as well as BC ratio to assess the system productivity.

Results and discussion

Effect of intercropping on yield and intercropping indices

Grain yield of browntop millet was influenced significantly with respect to browntop millet + legumes intercropping systems and row proportions (Table 1). Significantly higher grain yield was recorded in sole browntop millet (973.61 kg ha^{-1}) compared to different intercropping systems. The per cent yield increased with sole browntop millet was to the tune of 30.00, 33.24, 33.52 and 34.00 %, respectively over 4:2 row ratio of browntop millet + groundnut, browntop millet + soybean, browntop millet + green gram, browntop millet + black gram. Whereas, 2:1 row ratio was showed much less grain yield when compared to sole browntop millet. Among the different intercropping systems browntop millet + groundnut (674.31 kg ha^{-1}) with 4:2 row proportion was recorded numerically higher grain yield and numerically lower grain yield was recorded in browntop millet + black gram (637.04 kg ha^{-1}) at 2:1 row proportion. Because of 100 per cent plant population and less intercrop competition, the sole browntop millet recorded higher grain yield than different intercropping systems. This was in conformity with the findings of Sahu and Patro (1993), who found that when little millet was intercropped with green gram at 4:1 row proportion and black gram at 4:1 row proportion, as compared to little millet grown as a sole crop, a higher grain yield was obtained in sole little millet (654 kg ha^{-1}). Mitra *et al.* (2000) stated that, finger millet grown as a sole crop produced higher grain yield than finger millet grown in an intercropping system with green gram and soybean.

The significantly higher browntop millet equivalent yield (BMEY) was recorded in sole groundnut (3689 kg ha^{-1}), whereas, among the different intercropping systems browntop millet + groundnut in 4:2 row ratio (2326 kg ha^{-1}) was recorded numerically higher BMEY (Table 1). But sole browntop millet was recorded significantly lower browntop millet equivalent yield (973 kg ha^{-1}). Higher productivity of groundnut and higher market price of groundnut resulted in higher browntop millet equivalent yield. Numerically higher BMEY was recorded with 4:2 row ratio of browntop millet + groundnut. These results were conformity with findings of Kalaghatagi *et. al.,* (1995) where in pearl millet + groundnut with 2:4 row ratio produced higher yield of pearl millet equivalent. According to Sahu and Patro (1993), intercropping little millet and black gram in 2:1 row ratio resulted in a higher yield of little millet grain equivalent than sole little millet.

Land equivalent ratio (LER) of different intercropping systems were recorded significantly higher as compared to sole crop treatments (1.00). Among the different intercropping systems, browntop millet + black gram (1.192) with 4:2 row proportion was recorded numerically higher value and browntop millet + groundnut (1.127) at 2:1 row proportion was recorded numerically lower value (Table 1). It was due to the component crop's distinct phenological characteristics and ability to use growth resources and convert them into sink more effectively led to higher yield per unit area than that produced by sole crops, which was the obvious cause of the intercropping systems led yield advantages. According to Premsing *et. al.* (2007), intercropping of pearl millet and mothbean at 2:1 row ratio increased the LER (1.47). Based on pearl millet equivalent yield, net financial returns and LER, it was determined that the most productive, efficient and profitable combinations for rainfed conditions were pearl millet + moth bean (2:1) or pearl millet + cowpea (2:1). Ahmad and Prasad (1996) studied the LER of little millet + Groundnut in 4:1 and 6:1 row ratio which had higher overall values than pigeonpea as sole crop.

Area time equivalent ratio (ATER) of different intercropping systems was recorded higher values than all sole crops except browntop millet + groundnut (0.99) in 2:1 row proportion, but there was no significant difference observed among all the treatments. However, among different intercropping systems browntop millet + black gram (1.13) at 4:2 row ratio was recorded

Table 1. Grain yield of browntop millet, browntop millet equivalent yield (BMEY), land equivalent ratio (LER), area time equivalent ratio (ATER), system productivity index (SPI), agressivity, relative crowding co-efficient (RCC) as influenced by browntop millet + legumes intercropping systems

Tr.No.	Treatments	Yield (kg ha^{-1})	BMEY (kg ha^{-1})	LER	ATER	SPI	Agressivity		RCC
							Main Crop	Inter crop	
T_1	Browntop millet + groundnut (4:2)	674.31^{b}	2326^{b}	1.141^{a}	1.02^{a}	1110.84^{a}	-0.05^{a}	0.05^{e}	18.12^{a}
T_2	Browntop millet + soybean (4:2)	642.82^{b}	2229^{b}	1.152^{a}	1.03^{a}	1120.39^{a}	-0.08^{b}	0.08^{d}	16.06^{b}
T_3	Browntop millet + green gram (4:2)	642.36^{b}	1654^{cd}	1.183^{a}	1.07^{a}	1151.33^{a}	-0.10^{c}	0.10^{c}	15.90^{b}
T_4	Browntop millet + black gram (4:2)	640.74^{b}	1706^{c}	1.192^{a}	1.13^{a}	1159.49^{a}	-0.10^{c}	0.10^{c}	15.56^{b}
T_5	Browntop millet + groundnut (2:1)	665.51^{b}	2261^{b}	1.127^{a}	0.99^{a}	1086.32^{a}	-0.09^{bc}	0.09^{cd}	4.51^{c}
T_6	Browntop millet + soybean (2:1)	642.36^{b}	2222^{b}	1.150^{a}	1.03^{a}	1116.83^{a}	-0.16^{d}	0.16^{b}	4.28^{c}
T_7	Browntop millet + green gram (2:1)	637.64^{b}	1616^{cd}	1.162^{a}	1.05^{a}	1131.69^{a}	-0.18^{e}	0.18^{a}	3.87^{c}
T_8	Browntop millet + black gram (2:1)	637.04^{b}	1642^{cd}	1.158^{a}	1.10^{a}	1126.06^{a}	-0.18^{e}	0.18^{a}	3.79^{c}
T_9	Sole groundnut	-	3689^{a}	1.00^{b}	1.00^{a}	-	-	-	-
T_{10}	Sole soybean	-	1605^{cd}	1.00^{b}	1.00^{a}	-	-	-	-
T_{11}	Sole green gram	-	1054^{d}	1.00^{b}	1.00^{a}	-	-	-	-
T_{12}	Sole black gram	-	1420^{d}	1.00^{b}	1.00^{a}	-	-	-	-
T_{13}	Sole browntop millet	973.61^{a}	973^{c}	1.00^{b}	1.00^{a}	-	-	-	-
S.Em.±	27.72	79	0.047	0.044	49.15	0.004	0.004	0.541	

Note: means followed by the same letter(s) within the column did not differ significantly by DMRT (p= 0.05)

Table 2. Economics of browntop millet and legumes under sole and intercropping systems

Tr.No.	Treatments	Cost of cultivation(₹ ha^{-1})	Gross returns (₹ ha^{-1})	Net returns (₹ ha^{-1})	B:C ratio
T_1	Browntop millet + groundnut (4:2)	34426	72397^{b}	37971^{b}	2.10^{b}
T_2	Browntop millet + soybean (4:2)	34516	70455^{b}	35939^{bc}	2.04^{b}
T_3	Browntop millet + green gram (4:2)	32674	53186^{c}	20512^{c}	1.63^{c}
T_4	Browntop millet + black gram (4:2)	32648	54617^{c}	21969^{bc}	1.67^{c}
T_5	Browntop millet + groundnut (2:1)	34398	71555^{b}	37157^{b}	2.08^{b}
T_6	Browntop millet + soybean (2:1)	34500	70360^{b}	35859^{bc}	2.04^{b}
T_7	Browntop millet + green gram (2:1)	32670	52222^{c}	19552^{c}	1.60^{c}
T_8	Browntop millet + black gram (2:1)	32643	52985^{c}	20341^{c}	1.62^{c}
T_9	Sole groundnut	40504	113438^{a}	72934^{a}	2.80^{a}
T_{10}	Sole soybean	38907	101189^{a}	62282^{a}	2.60^{a}
T_{11}	Sole green gram	34276	62381^{bc}	28105^{bc}	1.82^{bc}
T_{12}	Sole black gram	34178	64199^{bc}	30020^{bc}	1.88^{bc}
T_{13}	Sole browntop millet	29005	31210^{d}	2205^{s}	1.08^{d}
S.Em.±	-	4621	4984	0.088	

Note: means followed by the same letter(s) within the column did not differ significantly by DMRT (p= 0.05)

numerically higher value (Table 1). Higher area time equivalent ratio and component crop yield in intercropping systems were primarily responsible for the higher ATER ratio with 4:2 row ratios. These findings were consistent with those results of Shashidhara *et. al.* (2000) who intercropped little millet, finger millet and foxtail millet with pigeonpea in a 4:2 row proportion recorded higher area time equivalent ratio. Prasannakumar *et. al.* (2009) reported that little millet + pigeonpea intercropped at a 6:2 row ratio recorded higher ATER values than the 3:1 row ratio.

There was no significant differences were observed among the different intercropping systems with respect to system productivity index (SPI). However, intercropping of browntop millet with blackgram (1159.49) at 4:2 row proportion was recorded numerically higher value and intercropping of browntop millet with groundnut (1086.32) in 2:1 row proportion was recorded numerically lower values of SPI (Table 1). This could be due to competition between intercrops for resources. Similar results were found by Amir *et al*. (2013) in barley and medic intercropping system at 4:2 row proportion, where they recorded higher SPI values when compared to other row proportions.

Browntop millet was shown significantly least aggressivity when it was intercropped with black gram (-0.18) and green gram (-0.18) at 2:1 row proportion. However, browntop millet + groundnut (-0.05) in 4:2 row proportion has recorded significantly higher aggressivity. Significantly higher aggressivity of intercrops was noticed in browntop millet + black gram (0.18) and green gram (0.18) at 2:1 row proportion and browntop millet + groundnut (0.05) in 4:2 row proportion recorded significantly lower values (Table 1). The intercrops were dominated over the main crop, this may be due to competitive characteristics and efficient utilization of available resources by intercrops resulted in high vegetative growth coupled with shading effect resulted in the increase of dominance power of intercrops over the main crop. Among the different intercropping systems the significantly higher relative crowding coefficient (RCC) was recorded with browntop millet + groundnut (18.12) at 4:2 row proportion. Significantly lower RCC was observed in browntop millet + black gram (3.79) with 2:1 row proportion, followed by browntop millet + green gram (3.87) at 2:1 row proportion (Table 1).

Effect of intercropping on economics

Significantly higher gross returns was recorded with sole groundnut (₹ 1,13,438 ha^{-1}) followed by sole soybean (₹ 1,01,189 ha^{-1}). However, among the different intercropping systems, browntop millet + groundnut (₹ 72,397 ha^{-1}) in 4:2 row proportion was recorded numerically higher gross returns (Table 2). Similar trend was noticed with net returns whereas, significantly higher net returns was recorded in sole groundnut (₹ 72,934 ha^{-1}), followed by sole soybean (₹ 62,282 ha^{-1}). Higher groundnut and soybean yield as well as higher market prices for these two crops were the primary reason for the higher gross returns and net returns. However, among the different intercropping systems, browntop millet + groundnut (₹ 37,971 ha^{-1}) at 4:2 row proportion was recorded numerically higher net returns (Table 2). This was mainly because of low market price of browntop millet and low productivity. These findings were in line with those made by Prasannakumar *et al.* (2009) who found that intercropping of pigeonpea and little millet in a horsegram sequence (6:2 row ratio) resulted in significantly higher gross returns than sole cropping. According to Kumaraswamy (1981), finger millet + soybean in paired rows had the highest net return when compared to finger millet as a sole crop. Significantly higher benefit cost ratio was recorded in sole groundnut (2.80), followed by sole soybean (2.60). However, among the different intercropping systems, browntop millet + groundnut (2.10) in 4:2 row proportion was recorded numerically higher benefit cost ratio. These results were consistent with those results of Singh and Arya (1999), who found that intercropping of finger millet with soybean at 4:2 row proportion increased the net returns and B:C ratio than sole finger millet.

Conclusion

Based on the economics, it was concluded that sole groundnut and sole soybean was more profitable than the

intercropping system. Sole groundnut was recorded significantly higher browntop millet equivalent yield (3689 kg ha^{-1}). Sole groundnut and sole soybean was recorded significantly higher net returns (₹ 1,01,189 ha^{-1} and ₹ 62,282 ha^{-1}, respectively) and benefit cost ratio (2.80 and 2.60 respectively). Among the different intercropping systems browntop millet + groundnut at 4:2 row proportion was recorded numerically higher net returns and benefit cost ratio (₹ 37,971 ha^{-1} and 2.10 respectively), it was also found better on the basis of yield and yield parameters. Among the different row ratios, 4:2 row ratio of browntop millet + legumes (groundnut, soybean, green gram and black gram) intercropping system was found more profitable than 2:1 row ratio, especially for medium and small scale farmers with limited resources.

References

Ahmad S and Prasad N K, 1996, Sustainable intercrop association of little millets with groundnut and pigeon pea. *Indian Journal of Agronomy,* 41(3): 254-258.

Ahuja K N and Singh S S, 1987, Response of sorghum legume intercropping systems to nitrogen and phosphorus in dryland conditions of north west India. *Indian Journal of Agronomy,* 32(3): 245- 249.

Amir S, Emad J, Masoud H, Alireza E and Stephen J H, 2013, Intercropping annual medic (*Medicago scutella* L.) with barley (*Hordeum vulgare* L.) may improve total forage and crude protein yield in semi-arid environment. *Australian Journal of Crop Science,* 7(12): 1822-1828

Kalaghatagi S B, Itnal C J, Jiral J A and Maead M S, 1995, Pearlmillet based intercropping system for Northern dry zone of Karnataka. *Indian Journal of Agronomy,* 40(3): 495-497.

Kumaraswamy A S, 1981, Studies on intercropping in finger millet with grain legumes indifferent planting patterns and plant populations under dryland agriculture. *Ph. D. Thesis*, University of Agricultural Sciences, Bangalore.

Mitra S, Ghosh D C, Sounda G and Jana P K, 2000, Performance of intercropping legumes in finger millet (*Eleusine coracana*) at varying fertility levels. *Indian Journal of Agronomy,* 46(1): 38-44.

Prasannakumar B H, Halikatti S I and Ninganur B T, 2009, Sustainable intercrop association of pigeonpea (*Cajanus cajan*) in little millet (*Panicum sumatrence* L.). *Karnataka Journal of Agricultural Sciences*, 22(4): 887-888.

Premsing P G, Pralhad D S and Sanjiv kumar C W, 2007, Effect of pearlmillet (*Pennisetum glaucum*) based intercropping system on yield and economics of pearl millet on shallow soils under rainfed conditions. *International Journal of Agricultural Sciences,* 3(2): 192-193.

Sahu D N and Patro H, 1993, Effect of intercropping littlemillet with pures under rainfed conditions. *Indian Journal of Agronomy,* 38(4): 633-635.

Shashidhara G B, Basavaraja R and Nadagouda B, 2000, Studies on pigeonpea intercropping systems in small millets under shallow red soils. *Karnataka Journal of Agricultural Sciences,* 13(1): 7-10.

Singh R V and Arya M P S, 1999, Nitrogen requirement of finge rmillet + pulse intercropping systems. *Indian Journal of Agronomy,* 44(1): 47-50.