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Performance of wheat (*Triticum aestivum* L.) succeeding pearlmillet intercropped in seed crop of *Sesbania*

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ABSTRACT

Sole pearlmillet and their intercropping combinations during *kharif* followed by wheat grown with three nitrogen levels *i.e* 50, 75 and 100 % of recommended dose of nitrogen (RDN) to identify the profitable system. Based on two year study the net return and B:C ratio under *Sesbania*–wheat rotation were 17.9% and 7.1% more over pearlmillet-wheat crop rotation, respectively. Among intercropping systems *Sesbania* sown at 90 cm spacing intercropped with one row of pearlmillet followed by wheat was the most profitable crop rotation for the farmers who are interested in seed crop of *sesbania* with net return (Rs 40013/ha) and B:C ratio (1.48) along with highest *Sesbania* seed yield of (924kg/ha) with an additional pearlmillet yield (743kg/ha) and wheat equivalent yield (6656kg/ha). *Sesbania* sown at 120 cm spacing intercropped with two rows of pearlmillet followed by wheat was the most profitable crop rotation for farmers, who are more interested in pearlmillet seed crop with the highest net return (Rs 40593/ha) and B:C ratio (1.48) along with highest pearlmillet seed yield (1344 kg/ha), *Sesbania* seed yield (762 kg/ha), highest *sesbania* equivalent yield (1379 kg/ha) and second highest wheat equivalent yield (6661kg/ha) among intercropping systems. So, *Sesbania* followed by wheat is more profitable over pearlmillet- wheat crop rotation and from sustainability point of view to encourage the farmers for seed production of *Sesbania* and to get maximum net return, the *Sesbania* can be intercropped with one or two rows of pearlmillet. *Sesbania* sole or in combination with pearlmillet as intercrop was found beneficial for soil health improvement in terms of available N,P and K status of soil as compared to pearlmillet sole-wheat rotation.

Key words: B:C ratio,Crop equivalent yield, Intercropping, Net return, Pearlmillet, *Sesbania aculeata*, Wheat.

INTRODUCTION

Haryana state of India is having only 1.4% (4.4 M ha) of the total geographical area of the country but produces 6.35% of the all India food grain production (2012-13). In last few decades, rice-wheat cropping system has emerged as a major production system in Haryana. India is now the second largest producer and consumer of wheat in the world. India harvested a record production of 84.27 million tonnes of wheat during the crop year 2010-11. In India, approximately 100 million tonnes of wheat would be required to be produced to cover an estimated demand for 345 million tonnes of food grains in 2030. Current agriculture in Haryana is confronted with formidable problems of stagnating production due to decline in factor productivity, degrading soil health, inefficiency of current production practices, scarcity of resources, high cost of cultivation and low returns to the farmers as ill effects of green revolution which concentrates on maximum output but overlooks input use efficiency. Thus recent nutrient-related stresses are becoming increasingly widespread in many soils due to non-use of organic manures and indiscriminate use of high-analysis fertilizers, leading to decline in organic carbon content of soil and low crop productivity and need to include legumes and green manure crops in cropping systems (Mahapatra *et al*., 2009). Organic matter is also the principal constituent of soils to support biodiversity and various regulatory processes involved in nutrient transformation and release. Moreover, declining availability and rise in fertilizer costs are forcing to evolve alternative strategies.

The problem is likely to be further exacerbated by the climate change which poses new threats for sustainability of major cropping systems in Haryana. So, the sustainability issues in the wheat cropping system will have to be addressed properly so that the long term growth as well as national food security and household nutritional security are not adversely affected. Thus to meet out the challenges imposed by overuse of natural resources and climate change in Haryana and to

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sustain productivity level with optimum use of agricultural inputs, some cropping system, resource conservation, socio-economic and policy based mitigation and adaptation measures like changing the cropping calendar and improved crop management through inclusion of legume and green manuring crops in crop rotations and intercropping of legumes with cereals/ millets have many potential benefits such as stable yields, better use of resources, weeds, pest and diseases reduction, increased protein content of cereals, reduced nitrogen leaching as compared to sole cropping systems (Venkateswarlu *et al.*, 2009). Crop diversification through intercropping has long been recognized as a kind of biological insurance against risks and climate changes. In general, grain yield of succeeding crop increased markedly when legumes preceded them compared with that when cereals preceded. Growing grain legumes and incorporating the residues into the soil not only increase the system productivity but also save the expenses on chemical fertilizer.

Legumes like *Sesbania aculeata* (dhaincha) being quick growing, succulent, easily decomposable, withstands salinity or alkalinity and poor drainage situation better as compared to other green manure crops, is widely used as green manure crop to increase the crop productivity of succeeding crops and to sustain the soil fertility (Das and Sudhishri, 2010). A lot of research work on *Sesbania aculeata* as green manure crop has been done, but very few research findings related to the seed production, agronomy and intercropping under this crop are found in literature. The constraints in the popularization of *Sesbania aculeata* as green manure crop is inadequate availability of quality seeds at reduced cost due to its low seed production and poor economics (Selvi and Kalpana, 2008). Keeping the above facts in view, present investigation was undertaken to enhance the system yield and economics by growing pearlmillet (*Pennisetum glaucum*) as intercrop in seed crop of dhaincha (*Sesbania aculeata*) during *kharif* followed by wheat during *rabi* season.

MATERIALS AND METHODS

A field experiment was carried out at agronomy research area of CCS Haryana Agricultural University, Hisar, Haryana, India ($29^0 10^0$N latitude, $75^0 46^0$E longitude and 215.2 M altitude) during 2010-11 and 2011-12 in randomized block design, replicated thrice with ten treatment combinations during k*harif* season (Table 1) , while during *rabi* season all these ten treatment combination of intercropping were split in to three levels of nitrogen fertilization i.e. 50%,75% and 100% of recommended dose of nitrogen (RDN) and replicated thrice. Hisar has a semi-arid and sub-tropical climate with hot, dry and desiccating winds during summer and severe cold during winter season. The mean maximum and minimum temperature, relative humidity and total rainfall during crop duration from 6th December, 2010 to 20th April, 2011 and during 12th December, 2011 to 25th April, 2012 are given in Table 6. The soil of the field was sandy loam in texture, slightly alkaline in pH (8.0), low in organic carbon, poor in available nitrogen and medium in available phosphorus and rich in available potassium. *Sesbania aculeata* variety 'DH-1' for seed purpose, 'HHB 67-2' hybrid of pearl millet and 'WH 711' of wheat were used. The wheat crop was sown and harvested on 6th December and 20th April and 12thDecember and 25th April during first and second year, respectively. All the crops were

TABLE 1: Effect of different intercropping systems on *Sesbania aculeata* and pearlmillet yield.

Treatments	***Sesbania aculeata* seed yield (kg/ha)**			**Pearlmilletseed yield (kg/ha)**			***Sesbania* Equivalent Yield (kg/ha)**		
	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled
T_1 – *Sesbania* sole at 60 cm spacing	1033	1042	1037	-	-	-	1033	1042	1037
T_2 - *Sesbania* sole at 45 cm spacing	1023	1066	1045	-	-	-	1023	1066	1045
T_3 – Pearlmillet sole at 45 cm spacing	-	-	-	2230	1909	2069	1090	933	1012
T_4 - *Sesbania* at 90cm spacing + One row of Pearlmillet	944	903	924	833	652	743	1352	1222	1287
T_5 – Paired row of *Sesbania* at 45cm : 90 cm+ One row of Pearlmillet	764	779	772	477	534	505	998	1040	1019
T_6 – *Sesbania* at 120cm spacing + One row of Pearlmillet	830	863	847	1084	620	852	1372	1156	1264
T_7 - *Sesbania*at 120cm spacing + Two row of Pearlmillet	745	700	723	1546	1142	1344	1468	1291	1379
T_8 - Paired row of *Sesbania*at 45cm: 120 cm+ Two row of Pearlmillet	759	746	753	956	716	836	1227	1096	1161
T_9 - Paired row of *Sesbania* at 60cm: 120 cm+ Two row of Pearlmillet	669	690	679	890	700	795	1104	1032	1068
T_{10} -Paired row of *Sesbania* at 60cm: 120 cm+ One row of Pearlmillet	855	840	848	694	571	632	1194	1119	1157
CD at 5%	124	102	78	166	98	104	153	161	179
SE(m)±	41	34	25	55	33	35	0.24	0.31	0.20

taken with recommended package of practices and the soil samples were collected before the sowing of crop and after the harvesting of crop. The available N, P, K in kg/ha and organic carbon (%) were estimated as per the method suggested by Chopra and Kanwar (1991). To record the yield attributing characters of crops three plants per plot were tagged and the seed as well as biological yield harvested per plot was converted in to kg/ha basis. The economics of different treatments was calculated by using the data provided by the department of economics, CCS, Haryana Agricultural University, Hisar and the MSP recommended by the ministry of agriculture, India.

RESULTS AND DISCUSSION

A) K*harif* Season *(Sesbania aculeata* and pearlmillet): Based on two year study, it is evident from data in Table1 that *Sesbania* sole crop planted at 45 cm spacing obtained highest seed yield of 1045 kg/ha with non-significant difference over *Sesbania* sole planted at 60 cm spacing. Among the intercropping systems, highest *Sesbania* seed yield of 924 kg/ha with a reduction of 11.6 % as compared to sole planted crop was obtain when sown at 90 cm spacing with alternate row of pearlmillet as inter crop. The lowest seed yield was obtained when two rows of pearlmillet were sown in between paired row of *Sesbania* at 60:120cm spacing with a reduction of 26.5% as compared to sole *Sesbania* planted at 45cm spacing. *Sesbania* seed yield was significantly reduced in all the intercropping systems as compared to sole crop of *Sesbania*. These results are also in agreement with findings of Pal *et al.* (2000), that there is significant reduction in seed yield of legume crops under intercropping systems with pearlmillet over sole crop. Among all the intercropping systems maximum *Sesbania* equivalent yield of 1379 kg/ha, which was 24.2% higher than sole crop of *Sesbania* at 45 cm spacing was obtained with two row of pearl millet intercropped in *Sesbania* sown at 120 cm spacing and it was significantly higher than all treatment except *Sesbania* sown at 90 cm and 120 cm spacing with one row of pearl millet as intercrop. Similar reduction in equivalent yield of sole crop over inter cropped treatment was observed by Padhi *et al.* (2010).

The data given in Table1 reveal that intercropping of pearlmillet in *Sesbania* reduced the seed yield of pearlmillet significantly in all the treatments as compared to sole crop except two row of pearlmillet intercropped in *Sesbania* sown at 120 cm spacing. Among all the intercropping systems highest seed yield with a reduction of 35.0% over sole crop was obtained with two rows of pearlmillet intercropped in *Sesbania* sown at 120 cm spacing and it was also significantly higher than all the intercropping systems. These results were in close conformity with findings of Ram *et al.*(2005), that the yield of intercropped pearlmillet with legumes reduced significantly over sole crop. Similar trend of observations was found in both the years of study, but the seed yield was higher during *kharif* 2010.

B) *Rabi* season Yield attributes of wheat: Data given in Table 2 revealed that sole *Sesbania*-wheat rotation was found with maximum value of all the yield attributes of wheat and pearlmillet-wheat rotation had least values. Total number of tillers/ metre row length, effective tillers/ metre row length, spike length, number of spikelet /spike, grains/spike and test weight of wheat were maximum when sown after *Sesbania* at 45cm registering an increase of 7.5%, 4.6%, 11.5%, 9.0%, 5.5% and 2.3%, respectively over sole pearlmillet– wheat rotation. These results were also supported by Singh *et al.*, (2003).

Among intercropping systems, maximum total number of tillers as well as effective tillers/metre row length, spike length, spikelet/spike and test weight were with paired row of *Sesbania* at 45:90 cm spacing intercropped with one row of pearlmillet succeeded by wheat but compared to sole *Sesbania*- wheat, the respective reduction in these yield attributes was 1.1%, 2.0%,1.8% and 1.0%. Crop rotation having two rows of pearlmillet intercropped in *Sesbania* sown at 120 cm followed by wheat was observed with minimum total no. of tillers as well as effective tillers/metre row length. Similar findings were also reported by Kumpawat and Rathore (2003).

Wheat fertilized with 100% of RDN *i.e.* 150 kg N/ ha significantly increased the total no. of tillers, no. of effective tillers per metre row length, spike length, spikelets/ spike, grains per spike and test weight with 8.1%,6.7%,7.8%, 7.9%,11.4% and 5.6% and 3.7%,2.6%, 3.9%, 4.6%, 5.9% and 1.8%, respectively gain over 50% RDN and 75% RDN. Wheat sown with 75% of RDN also exhibited significant increase in the total no. of tillers, effective tillers/meter row length, spike length, spikelets /spike, grains/spike and test weight over 50% RDN with a gain of 4.6%,4.3% ,4.0%,3.4%, 5.8% and 3.9**%,** respectively.

Similar trend of observation was found during both the years of study but yield attributers observed were more during *rabi* 2011-12 as compared to 2010-11.

Wheat yield &harvest index: On the basis of two year study as per the data shown in Table 3, it is concluded that, the highest seed yield (5482 kg/ha) and biological yield (12839 kg/ha) were observed in sole *Sesbania* (at 45 cm) followed by wheat crop rotation, which were significantly higher than all crop rotations tested and were 16.7% and 9.5% higher

TABLE 2: Effect of preceding intercropping systems and nitrogen levels on yield attributes of wheat.

Treatments	Total no. of tillers/mrl			No. of effective tillers/mrl			Spike length (cm)			Spikelets/spike			Grains/spike			Test weight(g)		
	10-11	11-12	Pooled	10-11	11-12	Pooled	10-11	11-12	Pooled	10-11	11-12	Pooled	10-11	11-12	Pooled	10-11	11-12	Pooled
T_1	114.8	118.4	116.6	98.1	99.0	98.5	9.6	10.8	10.2	21.1	22.8	21.9	41.3	41.6	41.4	43.1	43.9	43.5
T_2	115.7	119.1	117.1	99.1	99.8	99.4	9.8	11.1	10.4	21.4	23.0	22.2	41.4	42.3	41.9	13.3	44.1	43.7
T_3	107.8	108.8	108.3	94.8	94.9	94.8	9.1	9.4	9.2	20.0	20.3	20.2	39.2	40.1	39.6	42.4	43.1	42.7
T_4	112.6	116.3	114.4	96.1	97.0	96.5	9.4	10.6	10.0	20.8	21.7	21.2	40.8	41.6	41.2	42.7	43.6	43.1
T_5	114.3	117.3	115.8	97.9	98.8	98.3	9.5	10.7	10.1	21.1	22.6	21.8	41.2	42.0	41.6	42.9	43.7	43.3
T_6	111.9	114.7	113.3	95.7	96.7	96.2	9.3	9.7	9.5	20.5	21.5	21.0	40.6	41.3	40.9	42.6	43.4	43.0
T_7	110.7	109.8	110.2	95.0	95.6	95.3	9.2	9.5	9.3	20.1	21.0	20.5	40.0	40.3	40.1	42.4	43.2	42.8
T_8	110.1	111.1	110.6	95.5	96.0	95.7	9.2	9.6	9.4	20.6	21.3	20.9	40.3	40.7	40.5	42.5	43.3	42.9
T_9	113.1	116.8	114.9	96.7	97.8	97.2	9.4	9.8	9.6	21.0	22.0	21.5	41.0	41.8	41.4	42.7	43.6	43.0
T_{10}	113.8	117.1	115.4	97.4	98.3	97.8	9.4	10.1	9.7	21.0	22.3	21.6	41.1	41.9	41.5	43.0	43.8	43.4
CD at 5%	2.3	3.4	2.9	1.4	1.7	1.5	0.2	0.6	0.4	0.5	0.9	0.7	0.7	0.7	0.8	0.3	0.2	0.3
SE(m)±	0.8	1.1	1.0	0.5	0.6	0.5	0.1	0.2	0.1	0.2	0.3	0.2	0.2	0.2	0.3	0.1	0.1	0.1
N_1-50% RDN	108.9	110.6	109.8	93.8	94.6	94.2	9.2	9.9	9.5	20.2	19.6	19.9	38.5	38.5	38.8	41.3	42.7	42.0
N_2-75% RDN	116.2	114.0	115.1	97.2	99.6	98.4	9.6	10.2	9.9	20.9	20.1	20.6	40.9	40.9	41.2	43.4	44.1	43.7
N_3-100% RDN	119.8	119.3	119.5	99.9	102.1	101.0	9.9	10.7	10.3	21.5	21.8	21.6	43.2	43.2	43.8	44.2	44.8	44.5
CD at 5%	1.9	1.7	1.9	1.3	1.7	1.5	0.3	0.4	0.4	0.7	1.2	0.9	1.1	1.1	1.2	0.5	0.4	0.5
SE(m)±	0.6	0.6	0.6	0.3	0.5	0.5	0.1	0.1	0.1	0.2	0.4	0.3	0.3	0.3	0.4	0.1	0.1	0.1

than with sole pearlmillet– wheat rotation being the lowest yielder. Among intercropping, one row of pearlmillet intercropped in paired row of *Sesbania* at 45:90 cm followed by wheat rotation had maximum seed yield, biological yield and harvest index and this treatment was significantly superior to all the intercropping treatments except *Sesbania* as paired row at 60:120 cm spacing + one row of pearlmillet - wheat rotation. However, compared to sole *Sesbania* – wheat rotation, paired row of *Sesbania* (45:90 cm) - wheat rotation exhibited 5.3%, 2.3% and 3.0% reduction in seed yield, biological yield and harvest index.

The wheat sown with 100% of recommended dose of nitrogen (RDN) *i.e.* 150 kg N/ha after all the *kharif* season intercropping as well as sole crop treatments gave highest seed and biological yield with significant increase of 4.0% and 3.4%; and 12.0% and 10.5% over 75% RDN and 50% RDN, respectively. Similar trend of observations was found in both the years of study, but the overall production of wheat was more during *rabi*-2011-12 as compared to *rabi* 2010-11. These findings were also confirmed by Haque and Lupwayi (2003).

Sesbaina sole at 45cm followed by wheat was found with maximum harvest index value of 42.7, which was significantly higher than all the treatment except *Sesbania* sole at 60 cm - wheat and paired row of *Sesbania* at 45: 90 cm + one row of pearlmillet succeeded by wheat. The lowest harvest index with a reduction of 8.0% over *Sesbania* sole at 45cm - wheat was obtained in wheat sown after pearlmillet sole. Different nitrogen levels applied to all crop rotations did not show the significant differences in harvest index of wheat. Harvest indices of wheat in all the crop rotations studied were statistically at par.

C) Wheat equivalent yield of crop rotations: The highest wheat equivalent yield of whole crop rotation (6951 kg/ha) was found with *Sesbania* sole at 45cm followed by wheat, which was significantly higher than all the treatments and shown a significant increase of 13.8% over sole pearlmillet–wheat rotation. Among intercropping treatments, the highest wheat equivalent yield (6666 kg/ha) was found with paired row of *Sesbania* at 60:120 cm spacing + one row of pearlmillet succeeded by wheat closely followed by *Sesbania* at 90cm spacing + one row of pearlmillet followed by wheat with non-significant differences among all treatments except paired row of *Sesbania* at 45:90 cm or at 60: 120cm + two row of pearlmillet succeeded by wheat. Similar trend of observation was found during both the years of study but the more yield level was obtained during 2011-12 as compared to 2010-11. These results are in conformity with findings of Kumar and Prasad (1999).

TABLE 3: Effect of preceding intercropping systems and nitrogen levels on wheat yield.

Treatments	Seed yield (kg/ha)			Biological yield (kg/ha)			Harvest index (%)			Wheat equivalent yield (kg/ha)		
	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled
T_1 – Sesbania sole at 60 cm spacing fb wheat	4611	6053	5332	11988	13330	12659	38.4	45.5	42.1	6064	7518	6791
T_2 - Sesbania sole at 45 cm spacing fb wheat	4643	6320	5482	12076	13602	12839	38.4	46.5	42.7	6082	7820	6951
T_3 – Pearlmillet sole at 45 cm Spacing fb wheat	4374	4759	4567	11773	11459	11616	37.1	41.6	39.3	5907	6071	5989
T_4 - Sesbania at 90 cm spacing + One row of Pearlmilletfb wheat	4490	5202	4846	11802	12219	12011	38.0	42.6	40.4	6391	6920	6656
T_5 – Paired row of Sesbania at 45 cm: 90 cm.+ One row of Pearlmillet fb wheat	4564	5814	5189	11973	13102	12538	38.1	44.4	41.4	5949	7276	6612
T_6 – Sesbania at 120 cm spacing + One row of Pearlmillet fb wheat	4467	5245	4856	11851	12306	12078	37.6	42.6	40.2	6380	6885	6632
T_7 - Sesbania at 120 cm spacing + Two row of Pearlmilletfb wheat	4481	4960	4721	11878	11772	11825	37.7	42.2	39.9	6592	6730	6661
T_8 - Paired row of Sesbania at 45 cm: 120 cm+ Two row of Pearlmillet fb wheat	4480	5171	4826	12007	12076	12041	37.3	42.8	40.1	6205	6712	6458
T_9 - Paired row of Sesbania at 60 cm: 120 cm+ Two row of Pearlmillet fb wheat	4463	5322	4893	11905	12405	12155	37.4	43.0	40.3	6015	6773	6394
T_{10} -Paired row of Sesbania at 60cm: 120 cm+ One row of Pearlmillet fb wheat	4507	5571	5039	11965	12691	12328	37.6	43.9	40.8	6187	7145	6666
CD at 5%	128	248	153	69	456	279	0.6	2.5	1.5	206	128	116
SE(m)±	45	87.4	53.9	23	161	98.5	0.2	0.87	0.6	69	43	39
N_1- 50% RDN	3951	5294	4623	10726	12169	11448	36.9	43.4	40.4			
N_2- 75% RDN	4654	5440	5047	12271	12500	12386	37.9	43.5	40.7			
N_3- 100% RDN	4920	5591	5256	12768	12819	12793	38.5	43.6	41.1			
CD at 5%	33	104	63	398	427	292	NS	NS	NS			
SE(m)±	8.4	26.5	16.2	102	109	74.7	0.51	0.4	0.34			

Economics: As per the data given in Table 4**,** during both the year of study the least cost of cultivation (Rs. 77253/ha) was incurred over *Sesbania* sown at 60 cm row spacing followed by wheat and maximum cost (Rs. 84638/ha) was spent on *Sesbania* sown at 120 cm row spacing + two rows of pearlmillet succeeded by wheat closely followed by paired row of *Sesbania* at 45:120 cm spacing + two rows of pearlmillet followed by wheat. The gross return as well as net return was found more in sole *Sesbania*- wheat as compared to sole pearlmillet- wheat during both the year of study. Among all the crop rotations, *Sesbania* sown at 120 cm spacing intercropped with two rows of pearlmillet followed by wheat was found with maximum gross return of (Rs125231/ha), which was 2.6% and 8.4% more over sole *Sesbania* at 45 cm -wheat and sole pearlmillet- wheat crop rotations, respectively. The least gross return was obtained with pearlmillet-wheat rotation. Among intercropping treatments, paired rows of *Sesbania* at 45:120 cm or at 60:120cm along with two rows of pearlmillet as intercrop followed by wheat earned the least gross return.

Sesbania sole at 45 cm spacing followed by wheat had earned maximum net return of (Rs 43865/ha) and B: C ratio (1.56),which were 19.8% and 7.7% more than the minimum values with sole pearlmillet- wheat rotation. These findings were in accordance with the results of Bhushan and Omprakash, (2001). Among intercropping system, the highest net return of (Rs 40593/ha) was obtained with *Sesbania* sown at 120 cm spacing intercropped with two rows of pearlmillet succeeded by wheat closely followed by *Sesbania* sown at 90 cm spacing intercropped with one row of pearlmillet followed by wheat and it was 7.4% lower than sole *Sesbania* at 45cm - wheat rotation, but was 13.3% more profitable than sole pearlmillet at 45 cm spacing followed by wheat. Paired rows of *Sesbania* either at 45:120 cm or at 60:120 cm with two rows of pearlmillet followed by wheat were found with the least net returns with a reduction of 18.3% and 21.2%, respectively, over the highest net return with sole *Sesbania* at 45 cm - wheat rotation. Similar trend of observations was found during both the years of study but during 2011-12, among intercropping systems, maximum net return was found with paired row of *Sesbania* at 45:90 cm spacing intercropped with one row of pearlmillet succeeded by wheat closely followed by paired row of *Sesbania* at 60:120 cm spacing with one row of pearlmillet followed by wheat. Among intercropping systems, highest B:C ratio was found with *Sesbania* sown at 120 cm or 90 cm along with one row of pearlmillet followed by wheat and *Sesbania* at 120 cm with two rows of pearlmillet as intercrop followed by wheat. Similar trend was followed during both years but during 2011-12, the highest B:C ratio was found with paired row of *Sesbania* at 45:90 spacing or at 60: 120 cm along with one row of pearlmillet followed by wheat.

Soil analysis: Soil status before sowing and after harvest of pearlmillet + *Sesbania* (seed crop) intercropping followed by wheat crop is presented in the Table 5. It was observed that there was no significant difference in terms of EC of the

TABLE 4: Economics of Pearlmillet + *Sesbania* (seed crop)– wheat cropping system.

Treatments	Total cost of cultivation (Rs/ha)	Gross return (Rs/ha)			Net Return (Rs/ha)			B:C ratio		
		2010-11	2011-12	Pooled	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled
T_1 – Sesbania sole at 60 cm spacing *fb* wheat	77253	108160	130071	119116	30907	52818	41863	1.40	1.68	1.54
T_2 - Sesbania sole at 45 cm spacing *fb* wheat	78160	109209	134841	122025	31049	56681	43865	1.40	1.73	1.56
T_3 – Pearlmillet sole at 45 cm Spacing *fb* wheat	79495	113718	115657	114688	34223	36162	35193	1.43	1.45	1.44
T_4 - Sesbania at 90 cm spacing + One row of Pearlmillet *fb* wheat	83405	118889	127946	123418	35484	44541	40013	1.43	1.53	1.48
T_5 – Paired row of Sesbania at 45 cm: 90 cm+ One row of Pearlmillet *fb* wheat	83398	112388	131773	122081	28990	48375	38683	1.35	1.58	1.46
T_6 – Sesbania at 120 cm spacing + One row of Pearlmillet *fb* wheat	82188	117829	125941	121885	35641	43753	39697	1.43	1.53	1.48
T_7 - Sesbania at 120 cm spacing + Two row of Pearlmillet *fb* wheat	84638	123543	126919	125231	38905	42281	40593	1.46	1.50	1.48
T_8 - Paired row of Sesbania at 45 cm: 120 cm+ Two row of Pearlmillet *fb* wheat	84320	116027	124273	120150	31707	39953	35830	1.38	1.47	1.42
T_9 - Paired row of Sesbania at 60 cm: 120 cm+ Two row of Pearlmillet *fb* wheat	84018	111966	125208	118587	27948	41190	34569	1.33	1.49	1.41
T_{10} -Paired row of Sesbania at 60cm: 120 cm+ One row of Pearlmillet *fb* wheat	82180	113740	129541	121641	31560	47361	39461	1.38	1.58	1.48

*Rate of *Sesbania* seed, Pearlmillet seed and Wheat grain used in calculation were Rs. 1800, 880 and 1285 per quintal, respectively.

TABLE 5: Soil status after pearlmillet + *Sesbania* (seed crop) intercropping followed by wheat crop.

Treatments	EC(dS/m)		pH		OC (%)		N (kg/ha)		P (kg/ha)		K (kg/ha)	
	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12
T_1	0.32	0.34	7.60	7.57	0.40	0.48	200.0	240.0	14.9	15.2	145.7	166.7
T_2	0.32	0.36	7.72	7.68	0.41	0.49	205.0	245.0	15.1	15.8	149.7	170.0
T_3	0.29	0.38	7.52	7.48	0.33	0.41	165.0	205.0	12.1	13.5	155.7	177.7
T_4	0.27	0.36	7.79	7.71	0.39	0.45	195.0	225.0	13.9	14.2	138.5	160.7
T_5	0.27	0.34	7.90	7.87	0.40	0.47	200.0	235.0	14.6	14.5	140.2	159.5
T_6	0.28	0.32	7.92	7.88	0.38	0.45	190.0	225.0	13.8	14.3	140.0	156.2
T_7	0.26	0.30	7.79	7.70	0.35	0.42	175.0	210.0	13.0	13.6	134.0	152.5
T_8	0.32	0.40	7.81	7.69	0.36	0.43	180.0	215.0	13.5	13.8	166.2	189.5
T_9	0.30	0.39	7.54	7.48	0.40	0.46	200.0	230.0	14.1	14.2	153.7	176.2
T_{10}	0.36	0.40	7.84	7.78	0.40	0.47	200.0	235.0	14.5	15.0	138.2	157.5
CD at 5%	NS	NS	NS	NS	0.03	0.05	5.8	9.7	2.5	2.2	6.01	7.1
SE(m)±	0.01	0.02	0.07	0.08	0.01	0.02	2.0	2.90	0.8	0.7	2.12	2.5
N_1- 50% RDN	0.30	0.35	7.95	7.85	0.44	0.45	220.0	225.0	14.1	14.5	142.2	161.7
N_2- 75% RDN	0.29	0.34	7.87	7.78	0.45	0.46	225.0	230.0	14.9	15.1	146.0	166.5
N_3- 100% RDN	0.30	0.37	7.90	7.85	0.46	0.47	230.0	235.0	15.5	15.8	150.2	171.5
CD at 5%	NS	NS	NS	NS	NS	NS	4.02	5.4	NS	NS	NS	NS
SE(m)±	0.05	0.01	0.03	0.02	0.01	0.01	1.30	1.8	0.35	0.32	0.79	1.25

*Initial soil status at start of experiment in *Kharif* 2010-11 was EC= 0.27, pH =7.65, O.C. %= 0.35, N (kg/ha)=147, P (kg/ha)=12 and K (kg/ha)=147.5

TABLE 6: Weather data during crop season.

Year & Month	Max. Temp. (C^0)	Min. Temp. (C^0)	R.H. Morning (%)	R.H. Evening (%)	Bright sunshine (hrs.)	PAN evaporation (MM)	Rainfall (mm)	Rainydays (days)
				2010-11				
6th. Dec., 2010	20.9	4.6	94.2	49.5	5.6	1.4	43.6	3
Jan.,2011	16.9	4.2	93.9	53.1	5.0	1.2	0	0
Feb	22.7	8.1	95.1	52.1	6.9	1.9	34.8	5
March	28.6	11.4	91.8	44.7	8.0	3.0	12.5	4
Upto 19th. April,2011	32.7	15.1	84.9	45.5	8.1	5.0	35.2	5
Average/Total	24.4	8.7	91.9	48.9	6.7	2.5	125.8	17
				2011-12				
12th. Dec.,2011	20.9	2.4	97.4	42.9	6.3	1.2	0	0
Jan.,2012	18.4	4.8	95.8	51.3	4.8	1.4	14.4	1
Feb	21.1	5.3	86.8	40.3	6.9	2.2	0	0
March	28.7	10.6	83.1	32.0	8.1	3.8	0	0
Upto 25th. April,2012	34.2	18.1	74.0	38.6	8.4	5.6	32.8	5
Average/Total		8.2	87.4	41.0	6.9	2.8	47.2	6

soil although it was increased slightly as compared with the initial soil status. This might be due to the application of irrigation water with salt content or may be due to capillary rise of ground water with high salt solution because of high evaporative demand in this semi arid zone. This is the confirmation result suggested by Kumar *et al.*(2013). The pH of the soil before sowing and after harvest of the crop did not change significantly . The pH was observed lower in second year as compare to first year. The decreased in soil pH may be attributed to production of organic acid during decomposition of organic material. Antil *et al*. (2011) also reported decrease in soil pH with the long-term application of farmyard manure under pearl millet- wheat cropping system.

The organic carbon content of soil after the harvest of wheat crop increased which might be due to better plant growth and root system left higher organic residues in the soil. Several workers have observed organic carbon content of the soil increased with the application of different organic materials and inclusion of leguminous plants in cropping systems (Kumar and Balyan, 2001; Tonk *et al.,* 2000; Singh *et al.,* 2008). The soil organic matter plays an important role in improvement of soil physical, chemical and biological properties and ultimately increasing soil productivity and crop yields (Antil *et al*., 2011, Bhagat *et al*., 2003, Marinari *et al.,* 2000).

The available N status of soil samples after two year study was found highest with *Sesbania* sole followed by wheat (245 kg/ha), while least was observed with pearlmillet sole-wheat rotation. Among the intercropping systems *Sesbania* sown by paired row pattern either at 45:90 or 60:120 cm along with one row of pearlmillet followed by wheat was

found with highest available N content of soil. These results were also supported by Kumar *et al*. (2012). The available P content of the post-harvest soil samples increased significantly in both the year. This may be due to release of organic acid formed by decomposition of organic matter which comes to the soil solution and may cause mineralization of native organic matter or dissolution of other forms of P as reported by Gupta *et al.* (2004). Mean available K content of the soil after harvesting of the wheat increased significantly in the last year as compared with the first year and may be due to increase of organic matter content. This result confirms the findings of Bar-Tal *et al.* (2004). These results were also supported by Chandra (2011).

CONCLUSION

On the basis of this two year study it is concluded that net return and B:C ratio under *Sesbania*–wheat rotation was 17.9% and 7.1% more profitable over pearlmillet-wheat crop rotation. Among intercropping systems *Sesbania* sown at 90 cm row spacing intercropped with one row of pearlmillet followed by wheat was most profitable crop rotation for the farmers interested in seed crop of *Sesbania* with net return (Rs 40013/ha) and B: C ratio (1.48) along with highest *Sesbania* seed yield of (924 kg/ha), additional pearlmillet yield (743 kg/ha) and wheat equivalent yield (6656 kg/ha). Whereas *Sesbania* sown at 120 cm spacing intercropped with two rows of pearlmillet followed by wheat was the most profitable crop rotation for farmers interested in pearlmillet seed crop with highest net return (Rs 40593/ha) and B:C ratio (1.48) along with the highest pearlmillet seed yield (1344 kg/ha), *Sesbania* seed yield (762 kg/ha), highest *Sesbania* equivalent yield (1379 kg/ha) and second most wheat equivalent yield (6661kg/ha) among intercropping systems. *Sesbania* sole or in combination with pearlmillet as intercrop was found beneficial for soil health improvement in terms of available N, P and K status of soil as compared to pearlmillet sole-wheat rotation.

Sole *Sesbania* succeeded by wheat is more profitable over pearlmillet- wheat crop rotation. To improve the profitability and sustainability of pearlmillet-wheat rotation, pearlmillet should be sown as intercrop with *Sesbania* and for which, grow *Sesbania* at 90-120 cm row spacing with intercrop of 1-2 rows of pearlmillet.

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