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Yield and nutrient status in the soil after harvest of soybean and millets in intercropping systems

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Abstract
The field experiment was conducted at Agricultural Research Station Bailhongal, Belagavi district (Karnataka) to study on yield and nutrient status in the soil after harvest of soybean and millets in intercropping systems during *kharif* 2016. The experiment was laid out in Randomized Block Design with three replications. Treatment details are as follows, T_1 - Soybean + foxtail millet (2:1), T_2 - Soybean + foxtail millet (4:2), T_3 - Soybean + finger millet (2:1), T_4 - Soybean + finger millet (4:2), T_5 - Soybean + little millet (2:1), T_6 - Soybean + little millet (4:2), T_7 - Sole crop of soybean, T_8 - Sole crop of foxtail millet, T_9 - Sole crop of finger millet and T_{10} - Sole crop of little millet. The results concluded that, sole crop of soybean recorded significantly higher grain yield (2,255 kg ha^{-1}) as compared to any intercropping systems. It was on par with 4:2 row ratio of soybean + foxtail millet (1,697 kg ha^{-1}). Further, Sole foxtail millet recorded significantly higher grain yield (1,901 kg ha^{-1}) as compared to their yield in intercropping systems. Among the intercropping systems, higher grain yield of millet was recorded in 4:2 row ratio of soybean + foxtail millet (1,429 kg ha^{-1}) and it was on par with 2:1 row ratio of soybean + foxtail millet (1,419 kg ha^{-1}). Among the intercropping systems, significantly higher available nitrogen, phosphorus, potassium and sulphur was recorded in 2:1 row ratio of soybean + finger millet and it was on par with 2:1 row ratio of soybean + foxtail millet.

Keywords: Yield, millets, soybean, intercropping, nutrient available

Introduction
Intercropping implies growing two or more crops simultaneously in the same area in rows of definite geometrical pattern (De *et al.,* 1978) [12]. Intercropping in which crops of dissimilar growth habits are grown simultaneously in such a way that they do not affect the performance of each other adversely. The major objectives of intercropping are produce an additional crop, optimize the use of natural resources and stabilize the yield of crops. From several studies, it is clear that yield of cereal component is usually less affected by component crop densities and manipulation of spacing between component crop, yield and monetary advantage in intercropping can be possibly achieved by the selection of crop, manipulation of plant population and row arrangement.

Soybean is a major oil seed crop of the world grown in an area of 121.1 million hectare with production of 340.8 million tonnes and productivity of 2,810 kg ha^{-1} (Anon., 2016) [1]. In world, it is being cultivated mainly in USA, Brazil, China, Argentina and India. In India, it is grown over an area of 10.02 million hectare with production of 114.9 million tonnes and productivity of 1,047 kg ha^{-1} (Anon., 2016) [1].

On global basis minor millets are cultivated with an area of 4.17 million hectare with an annual production of 3.0 million tonnes with productivity of 901.7 kg ha^{-1}. Whereas in India, millets are being cultivated with an area of 1.88 million hectare producing 1.80 million tonnes with productivity of 1186 kg ha^{-1}. In Karnataka minor millets including ragi are cultivated with an area of 0.64 million hectare producing 1.0 million tonnes of grains with productivity of 1,512 kg ha^{-1}. While minor millet excluding finger millet are cultivated on an area of 0.2 lakh hectare with annual production of 0.1 lakh tonnes with productivity of 500 kg ha^{-1} **(**Anon., 2016) [1].

In recent years, there has been an increasing recognition of the importance of millets in India, since major cereals grown on good soils supplied with large quantity of fertilizers, irrigation and pesticide gives higher yields. Sahu (1965) [6] stated that the millets are the crops that have potentiality of contributing to increased food production, both in developing and developed countries. Millets are grown under harsh environmental conditions. Some of them are best suited to high soil moisture and drought situations.

Thus, they do not burden the state with demands for irrigation or power. Millets are adapted to a wide range of ecological conditions often growing on skeletal soils that are less than 15 cm deep. It does not demand rich soils for their survival and growth. Hence, for the rainfed land, they are a boon. They have remarkable rejuvenation capacity and recover very fast once the moisture stress conditions are alleviated. Because of their flexibility in adjusting to sowing time and the existing environmental conditions, Millet production is not dependent on the use of synthetic fertilizers. Most millet farmers therefore use farmyard manures and in recent times, household produced biofertilizers. Grown under traditional methods, no millet attracts any pest. They can be termed as pest-free crops. A majority of them are not affected by storage pests. Therefore, their need for pesticides is close to nil. Thus, they are a great boon to the agricultural environment. They are highly nutritive and are having short duration, to make better utilization of resources and space suited for intercropping systems. Although these minor millet is a very important millets in Karnataka and also in Northern Transitional Zone. Hence there is need to assess the nutrient status of soybean and millets in intercropping systems.

Materials and Methods

The field experiment was conducted at Agricultural Research Station (ARS), Bailhongal, during *kharif* 2016 which is situated in Northern Transitional Zone of Karnataka and located between $15^{0}81'$ North latitude and $74^{0}86'$ East longitudes with an altitude of 546 m above MSL. The soil type of experimental site was mixed red and black medium soil. The composite soil sample to a depth of 0 to 30 cm was collected before sowing and analyzed for physical and chemical properties. The soil was neutral in pH (7.1), normal in salt content (0.32 dS m^{-1}), medium in organic carbon content (0.56%), low in available nitrogen (220.9 kg ha^{-1}), medium in phosphorus (22.8 kg ha^{-1}), medium in potassium (296.6 kg ha^{-1}) and medium in sulphur (18.6 kg ha^{-1}). The experiment was laid out in Randomized Block Design with three replications. Treatment details T_1 - Soybean + foxtail millet (2:1), T_2 - Soybean + foxtail millet (4:2), T_3 - Soybean + finger millet (2:1), T_4 - Soybean + finger millet (4:2), T_5 - Soybean + little millet (2:1), T_6 - Soybean + little millet (4:2), T_7 - Sole crop of soybean, T_8 - Sole crop of foxtail millet, T_9 - Sole crop of finger millet and T_{10} - Sole crop of little millet. Data was calculated on yield and nutrient status in the after harvest of millets crops. The data collected from the experiment were analyzed statistically following the procedure as described by Gomez and Gomez (1984) [3]. The level of significance used in 'F' test was P = 0.05. Critical difference values were calculated wherever the F test was significant.

Results and Discussion

Soybean and millet grain yield

The grain yield results presented in Table 1. Sole crop of soybean significantly higher grain yield (2,255 kg ha^{-1}) as compared to any intercropping systems. It was on par with 4:2 row ratio of soybean + foxtail millet (1,697 kg ha^{-1}). Significantly lower soybean seed yield was recorded in 2:1 row ratio of soybean + little millet (1,501 kg ha^{-1}) compared to other treatments (Table 1). Further, Sole millets recorded significantly higher grain yield (foxtail millet- 1,901 kg $ha^{-1,}$ Finger millet-1,804 kg ha^{-1}, and little millet-1,521 kg ha^{-1}). Among the intercropping systems, higher grain yield of millet was recorded in 4:2 row ratio of soybean + foxtail millet (1,428 kg ha^{-1}) and it was on par with 2:1 row ratio of soybean + foxtail millet (1,418 kg ha^{-1}). Significantly lower grain yield of millets was recorded in 2:1 row ratio of soybean + little millet (1,177 kg ha^{-1}) compared to rest of the treatments. The similar results were reported by Nigade *et al*. (2012) [4] revealed that the black gram or moth bean as an intercrop in 8:2 or 4:1 row proportion in finger millet increased the grain yield to the tune of 42 to 57 per cent over sole cropping.

Soybean seed equivalent yield (SSEY)

The data on soybean seed equivalent yield are presented in Table 2. Significantly higher soybean seed equivalent yield was recorded in 4:2 row ratio of soybean + foxtail millet (2,334 kg ha^{-1}). It was on par with 2:1 row ratio of soybean + foxtail millet (2,310 kg ha^{-1}). Significantly lowest soybean seed equivalent yield was recorded in sole crop of little millet (1,521 kg ha^{-1}). Higher SSEY in 4:2 row ratio was due to higher contribution by soybean and millets and their market price coupled with better utilization of resources by the component crops in intercropping system. The results are corroborated with the findings of Shivaraj (2015) [7] at Dharwad who reported that, the highest GPEY (groundnut pod equivalent yield) was recorded with finger millet (2,916 kg ha^{-1}) followed by foxtail millet (2,792 kg ha^{-1}) and little millet (2,581 kg ha^{-1}) in 4:2 row ratio.

Available nutrient status after harvest of crops

The results of available nutrient status in the soil are presented in Table 2. Sole finger millet recorded significantly higher available nitrogen, phosphorus, potassium and sulphur content in the soil. Among the intercropping systems, significantly higher available nitrogen, phosphorus, potassium and sulphur was recorded in 2:1 row ratio of soybean + finger millet and it was on par with 2:1 row ratio of soybean + foxtail millet. The higher available which might be due lower uptake by the crops. Similar results were obtained by Rashmi (2010) [5] in French bean + finger millet intercropping system and Shivaraj (2015) [7] in groundnut + minor millet intercropping system. Further pH, EC and OC of soil after harvest of crop did not differed significantly.

Table 1: Grain yield and intercropping indices as influenced by soybean based millets intercropping systems

Treatments	Soybean grain yield (kg ha^{-1})	Millet grain yield (kg ha^{-1})	Soybean seed equivalent yield (kg ha^{-1})
Soybean + foxtail millet (2:1)	1,673	1,419	2,310
Soybean + foxtail millet (4:2)	1,697	1,429	2,334
Soybean + finger millet (2:1)	1,528	1,302	2,116
Soybean + finger millet (4:2)	1,531	1,308	2,120
Soybean + little millet (2:1)	1,502	1,178	1,940
Soybean + little millet (4:2)	1,504	1,202	1,959
Sole soybean	2,255	-	2,255
Sole foxtail millet	-	1,901	1,901
Sole finger millet	-	1,805	1,805
Sole little millet	-	1,521	1,521
S.Em. ±	36.4	8.7	73.3
C.D. at 5%	105.0	25.1	211.7

Note: Market price of the produce as per CACP-2017 (commission on agricultural costs and prices) Soybean-` 2,900 $q^{-1}$, Foxtail millet- ` 2,200 $q^{-1,}$ Finger millet- ` 2,200 $q^{-1}$ and little millet-` 2,100 q^{-1}

Table 2: Available nutrient status in the soil after harvest of soybean- millet intercropping systems

Cropping system	N (kg ha^{-1})			P_2O_5 (kg ha^{-1})			K_2O (kg ha^{-1})			S (kg ha^{-1})		
	2:1	4:2	Mean	2:1	4:2	Mean	2:1	4:2	Mean	2:1	4:2	Mean
Soybean + foxtail millet	185.43	173.97	179.70	21.53	21.62	21.58	190.37	181.63	186.00	15.70	16.14	15.94
Soybean + finger millet	201.00	191.63	196.32	22.31	22.19	22.19	193.03	184.50	188.77	16.18	16.00	16.09
Soybean + little millet	185.50	181.87	183.69	22.40	22.35	22.35	186.20	184.63	185.42	16.17	15.92	16.03
Sole soybean	-	-	171.43	-	-	20.25	-	-	175.07	-	-	16.68
Sole foxtail millet	-	-	211.30	-	-	23.61	-	-	201.90	-	-	16.03
Sole finger millet	-	-	209.63	-	-	23.07	-	-	185.27	-	-	15.67
Sole little millet	-	-	215.33	-	-	23.76	-	-	201.70	-	-	15.85
S.Em. ±	1.94			0.93			2.23			0.20		
C.D. at 5%	5.75			NS			6.63			NS		

Note: Initial available nitrogen 220.9 kg ha^{-1} (low), available phosphorus 22.8 kg ha^{-1} (medium), available potassium 296.6 kg ha^{-1} (medium) and available sulphur 18.6 kg ha^{-1} (medium).
NS – Non-significant

Table 3: Effect of soybean + millet intercropping systems on pH, EC and OC of soil after harvest

System	pH			EC (dS m^{-1})			OC (%)		
	2:1	4:2	Mean	2:1	4:2	Mean	2:1	4:2	Mean
Soybean + foxtail millet	6.96	6.95	6.95	0.31	0.30	0.35	0.56	0.55	0.55
Soybean + finger millet	6.94	6.90	6.92	0.31	0.30	0.35	0.54	0.53	0.53
Soybean + little millet	6.87	6.90	6.88	0.32	0.31	0.31	0.53	0.55	0.54
Sole soybean	-	-	7.11	-	-	0.31	-	-	0.56
Sole foxtail millet	-	-	7.04	-	-	0.32	-	-	0.57
Sole finger millet	-	-	6.95	-	-	0.30	-	-	0.56
Sole little millet	-	-	6.92	-	-	0.31	-	-	0.56
S.Em. ±	0.28			0.01			0.02		
C.D. at 5%	NS			NS			NS		

Note: Initial organic carbon 0.54%, pH 7.1 and EC 0.32 dS m^{-1}.
NS – Non-significant

Conclusion

The results concluded that, among the intercropping system, soybean + foxtail millet found higher soybean seed equivalent yield over other soybean based millets cropping system.

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