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Productivity and nutrient uptake of soybean and millets in intercropping systems

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Abstract
A field experiment was conducted on productivity and nutrient uptake of soybean and millets in intercropping systems during *kharif* 2016 at Agricultural Research Station Bailhongal, Belagavi district (Karnataka). 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. 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}). With respect to nutrient uptake, 4:2 row ratio of soybean + millet recorded higher uptake of nitrogen, phosphorous, potassium and sulphur in soybean as compared to 2:1 row ratio.

Keywords: Yield, millets, LER, ATER, nutrient uptake

Introduction
Intercropping of different cereals, millets, pulses and oilseed crops simultaneously on the same piece of land with or without any row will minimizes the risk of crop failures, acts as barrier for pests, improves soil fertility and makes the farmer self-sufficient. It is often stated that pests will be less damaging in fields with a mixture of crops than in fields with a single crop, also known as monocultures (Willey, 1979) [5].

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]. Soybean is an introduced and commercially exploited crop in India. The crop is also called as "Golden bean" or "Miracle crop" of the 21st century on account of its multiple uses. It has highest protein (40%), rich in oil (20%), lysine and vitamins A, B and D. It is also rich source of minerals and essential amino acids. Hence it is highly potential crop among grain legume crops for combating acute malnutrition.

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].

Minor millets are known as famine reserves as they can come up very well in low moisture conditions. 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. Based on the above facts, a field experiment was conducted at Agricultural Research Station, Bailhongal, during *kharif* 2016 to assess the Productivity and Nutrient uptake 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, Land equivalent ratio, Area time equivalent ratio and nutrient uptake by crops. The data collected from the experiment were analyzed statistically following the procedure as described by Gomez and Gomez (1984). 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 results showed 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}). 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 foxtail millet recorded significantly higher grain yield (1,901 kg ha^{-1}) 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 (1,428 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.

Soybean seed equivalent yield (SSEY)

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) [4] 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.

Land equivalent ratio (LER) and Area time equivalent ratio (ATER)

Significantly higher land equivalent ratio and area time equivalent ratio was recorded by 4:2 row ratio of soybean + foxtail millet and 2:1 row ratio of soybean + foxtail millet compared to any intercropping systems.

Intercropping of soybean + foxtail millet in 4:2 row ratio recorded significantly higher LER (1.50). It was on par with 2:1 row ratio of soybean + foxtail millet (1.49) and 4:2 row ratio of soy bean + finger millet (1.47). Lower LER was recorded 2:1 row ratio of soybean + little millet (1.37). The obvious reason for yield advantage in intercropping system was due to fact that the component crops differed in phenological character and utilization of growth resources and converting them into sink more efficiently resulting in higher yield per unit area than that produced by sole crops. Similar results were obtained by Narendra *et al.* (2010) [2] Similarly highest LER was obtained with horsegram + finger millet intercropping (1.39) followed by horsegram + maize (1.29) and lowest values was recorded in horsegram + pigeonpea intercropping (1.21). Yamuna *et al.* (2015) [6] reported that, significantly higher land equivalent ratio (1.85) and area time equivalent ratio (1.49) were recorded with paired row maize intercropped with pigeonpea at 45X75 cm spacing as compared to sole maize.

Higher ATER value was recorded in 4:2 row ratio of soybean + little millet (1.48). It was on par with 2:1 row ratio of soybean + little millet (1.46) and 4:2 row ratio of soybean + foxtail millet (1.40). Lower ATER was recorded 2:1 row ratio of soybean + finger millet (1.28) (Table 1). Increase in ATER values in little millet intercropping system was mainly due to its short duration compared to foxtail millet and little millet. The results are similar with the findings of Yogesh *et al.* (2011) [7].

Nutrient uptake by system

Among the intercropping systems, 4:2 row ratio of soybean + millet recorded higher uptake of nitrogen, phosphorous, potassium and sulphur in soybean as compared to 2:1 row ratio. Nutrient uptake by intercropping system as a whole is significantly higher compared to sole crop. The obvious reason could be utilization of resources with regard to the plant nutrients present in the soil or added to it as manure which would be utilized to the fullest extent in mixed stand than when components were grown separately. The different crops having varying root depths extract moisture and nutrients from different soil layers. Similar results were obtained by Rashmi (2010) [3] in French bean + finger millet intercropping system and Shivaraj (2015) [4] in groundnut + minor millet intercropping system.

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})	LER	ATER
Soybean + foxtail millet (2:1)	1,673	1,419	2,310	1.49	1.39
Soybean + foxtail millet (4:2)	1,697	1,429	2,334	1.50	1.40
Soybean + finger millet (2:1)	1,528	1,302	2,116	1.45	1.28
Soybean + finger millet (4:2)	1,531	1,308	2,120	1.47	1.29
Soybean + little millet (2:1)	1,502	1,178	1,940	1.37	1.46
Soybean + little millet (4:2)	1,504	1,202	1,959	1.39	1.47
Sole soybean	2,255	-	2,255	1.00	1.00
Sole foxtail millet	-	1,901	1,901	1.00	1.00
Sole finger millet	-	1,805	1,805	1.00	1.00
Sole little millet	-	1,521	1,521	1.00	1.00
S.Em. ±	36.4	8.7	73.3	0.01	0.01
C.D. at 5%	105.0	25.1	211.7	0.02	0.02

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: Nutrient uptake by system (both soybean and millets) as influenced by intercropping systems

Cropping system	N (kg ha^{-1})			P (kg ha^{-1})			K (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	107.99	119.37	113.68	28.35	31.41	29.88	85.12	92.30	88.71	14.28	15.18	14.73
Soybean + finger millet	112.58	121.58	117.08	29.03	31.45	30.24	91.21	98.28	94.74	14.10	15.54	14.82
Soybean + little millet	107.92	111.54	109.73	27.76	28.39	28.08	88.55	89.81	89.18	14.56	15.16	14.86
Sole soybean	-	-	124.54	-	-	25.20	-	-	25.20	-	-	19.98
Sole foxtail millet	-	-	37.60	-	-	17.16	-	-	17.16	-	-	9.30
Sole finger millet	-	-	55.86	-	-	20.94	-	-	20.94	-	-	8.34
Sole little millet	-	-	36.92	-	-	18.50	-	-	18.50	-	-	8.68
S.Em. ±	3.57			0.82			0.48			0.33		
C.D. at 5%	10.59			2.44			1.49			1.02		

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)

Conclusion

The results concluded that soybean + foxtail millet found superior over other soybean based millets cropping system with respect to yield, nutrient uptake and yield advantage analysis as compared others.

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