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Feasibility of kodo millet as an intercrop and integrated nutrient management in soybean

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Abstract
The field experiment entitled "Studies on Nutrient Management of Soybean + Kodo millet Intercropping System" was conducted during *kharif* season 2015 at Agronomy Research Farm, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. Experimental results revealed that growth characters were significantly higher in soybean with sole soybean cropping system followed by soybean + kodo millet (4:2) cropping system. Yield attributes, grain yield and straw yield were significantly higher with sole soybean system. Among the fertilizer levels, significantly higher growth attributes, yield attributes, seed straw and biological yield and yield of soybean crop were recorded under 100% RDF + 5 tons FYM fallowed by 100% RDF. In kodo millet, significantly higher growth characters were recorded with soybean + kodo millet (4:2) cropping system. Grain yield and straw and biological yield was higher in sole kodo millet cropping system. Significantly higher growth attributes, yield attributes and yield of kodo millet recorded under 100% RDF + 5 tons FYM fallowed by 100% RDF. Gross Monetary Returns, Net Monetary Returns and B: C ratio was higher with sole kodo millet cropping system and in different fertilizer levels GMR was higher with 100% RDF + 5 tons FYM and NMR and B:C ratio was higher with 100% RDF.

Keywords: Feasibility, kodo millet, intercrop, integrated nutrient management, soybean

Introduction
Intercropping has various benefits associated with it viz., better utilization of nutrient, space and reduced risk of crop failure due to weed, insect and climate vagaries. Among all the use of intercrop, improving nutrients use efficiencies is one of the important aspects. Intercropping provides possibility of lower labor requirement, stability of yield, greater nutrient uptake and higher productivity per unit land area (Sankaranarayanan *et al*. 2011) [11]. Amongst all crops, legumes are better suited because almost all legumes are able to exploits atmospheric nitrogen at varying degree and thus help in achieving N economy. In Maharashtra, area under soybean is 37.74 lakh ha with production of 26 lakh metric tons and productivity of 825 kg/ha (Anonymous 2015). There is a need to improve the productivity and sustainability of soybean under *rainfed* conditions by improving the utilization of the received rainfall with a suitable cropping system and optimal input fertilizers. Kodo millet can be grown with very low competition from other plants and weeds for nutrients, poor nutrient soil and scanty and erratic rainfall in the areas receiving rainfall of only 40-50cm. The grain contains 8.3% protein, 1.4% fat, 65.61% carbohydrates and 2.9% ash. The stover is good fodder for cattle (Pradhan *et al*, 2014) [10]. Hence, it was felt necessary to popularize the cultivation of soybean and kodo millet by adopting the intercropping system.
Fertilizer application is one of the major factors which could increase soybean production on per unit basis. Among the fertilizer nutrients applied, nitrogen is being used more extensively. Application of excessive amounts of nitrogen fertilizer may reduce profitability and create groundwater pollution hazards. Soybean have an extensive root system which may help in utilizing residual soil nutrients. Hence efforts have been made to Study on Nutrient Management of Soybean + Kodo millet Intercropping System.

Materials and methods
The experiment on Nutrient Management of Soybean + Kodo millet Intercropping System was laid out in factorial randomized block design with three replications. The soil of experimental plot was clayey in nature having pH 8.1and EC 0.23 ds m^{-1}, low in both available N (222 kg ha^{-1}) and P_2O_5 (15.86 kg ha^{-1}), high in K_2O (348 kg ha^{-1}). The experiment consisted of twelve

treatment combinations, comprising of four types of cropping system viz., sole soybean, soybean + kodo millet 4:2, soybean + kodo millet 3:3, sole kodo millet and three fertilizer levels viz., 100 percent RDF (N_1), 100 percent RDF + 5 tons FYM (N_2) and 50 percent RDF + 5 tons FYM (N_3). Treatment wise cropping system and fertilizers were applied to soybean and kodo millet, and nitrogen, total rainfall during the crop season was 640 mm.

Result and discussion

Effect on growth

Soybean.

Among the cropping systems, cultivation with sole soybean recorded maximum plant height number of leaves per plant, leaf area plant $^{-1}$ and dry matter production per plant which were significantly superior over soybean + kodo millet intercropping system of 4:2 and 3:3 row proportion. This might be due to tallness of plants in sole soybean associated with no competitive effect for space, moisture, nutrient and light further accelerated the phototropism and there by increased the plant height of soybean. Similar result were recorded by Shrivastava *et al*. (2014) [13].

In respect of different fertilizer levels, maximum plant height (62.40cm), number of leaves per plant (12.02), leaf area plant^{-1} (12.73 dm^2), and dry matter accumulation (24.04 g) was recorded with 100 percent RDF + 5 tons FYM, which was significantly superior over 50 percent RDF + 5 tons FYM but at par with 100 percent RDF. The increase in plant height with increase in nutrient management might be attributed to greater availability of nutrients with increase in application rate which have favorable influence on plant growth. Nitrogen has property to increase all the vital physiological processes, which in turn facilitated translocation of photosynthates to the growing meristematic tissues. It is well documented fact that application of phosphorus assists in absorption of metabolites, water and its further transformation for the growth of plant in terms of height. Application of potassium helps in activation of enzymes in meristematic tissue and play decisive role in cell wall plasticity resulting in increased growth. Similar result were recorded by Kushwaha and Chandel (1997) [7].

Kodo millet

Significant differences on growth of kodo millet were observed with different cropping systems. Cultivation with soybean + kodo millet intercropping system of 4:2 row proportion recorded maximum plant height of kodo millet (59.33cm), number of leaves per plant (2.62), and these were significantly superior over sole kodo millet and at par with soybean + kodo millet intercropping system of 3:3 row proportion.

Significant differences in respect of growth habits of kodo millet were recorded due to different levels of fertilizer. Maximum plant height (62.18 cm), number of leaves per plant (11.89), dry matter accumulation plant^{-1} (7.28) was recorded at harvest with 100 percent RDF + 5 tons FYM, which was significantly superior over 50 percent RDF + 5 tons FYM (57.38 cm) and at par with 100 percent RDF (62.10 cm). This might be due to the higher level of fertilizer doses applied to the crop resulting in the faster growth due to higher uptake NPK. This result was also supported by Pradhan *et al*. (2014) [10].

The interaction effect among the treatments for all the growth factors of kodo millet were found non-significant.

Effect on yield attributes

Soybean

The number of pods plant^{-1} was significantly increased with cropping system. The maximum number of pods per plant (49.5), maximum weight of pods per plant (11.45 g), seed yield plant^{-1} (7.17g) and 100 seed weight (9.61g) was recorded with sole soybean, which was significantly superior over soybean + kodo millet intercropping system of 4:2 (45.29) and 3:3 (45.29) row proportion. About 9.31 percent increase was observed with sole soybean than soybean + kodo millet in 4:2 and 3:3 row proportion. Increase in number of pods plant $^{-1}$ with sole soybean over intercropped soybean was also reported by Shrivastava *et al*. (2014) [13].

Table 1: Growth characters of soybean and kodo millet as influenced by different reatments

Treatment	soybean				kodo millet		
	Height (cm)	No. of Leaves plant^{-1}	Leaf area plant^{-1} (dm^2)	Dry matter plant^{-1} (g)	Height (cm)	No. of Leaves plant^{-1}	Dry matter plant^{-1} (g)
A. Cropping system							
C1- Sole soybean/ kodo millet	59.33	2.62	12.98	27.62	62.40	12.02	7.28
C2- soybean + kodo millet(4:2)	54.67	1.93	11.92	21.23	62.09	11.40	7.24
C3- Soybean + Kodo millet (3:3)	54.33	1.93	11.89	20.90	57.17	10.07	6.18
SE(m)±	0.91	0.12	0.27	0.65	1.38	0.52	0.17
CD at 5%	2.74	0.37	0.82	1.93	4.13	1.56	0.51
B. Fertilizer levels							
N1- 100% RDF	57.22	2.13	12.59	23.94	62.10	11.57	7.10
N2-100%RDF+ 5 tons FYM	57.33	2.27	12.73	24.04	62.18	11.89	7.28
N3-50% RDF+5 tons FYM	53.78	2.09	11.46	21.76	57.38	10.03	6.32
SE(m)±	0.91	0.12	0.27	0.65	1.38	0.52	0.17
CD at 5%	2.74	NS	0.82	1.93	4.13	1.56	0.51
Interaction A× B							
SE(m)±	1.58	0.23	0.47	1.12	2.38	0.90	0.29
CD at 5%	NS	NS	NS	NS	NS	NS	NS

Application of 100 percent RDF + 5 tons FYM recorded maximum number of pods per plant (48.2), The maximum weight of pods plant^{-1} (10.7 g), seed yield plant^{-1} (7.2g) and 100 seed weight (9.33g) which was significantly superior over 50 percent RDF + 5 tons FYM (43.63) and at par with 100 percent RDF (48.21). About 10.56 percent more number of pods plant^{-1} were recorded with 100 percent RDF + 5 tons FYM as compared to 50 percent RDF. Similar result was recorded by Jayapaul and Ganesaroja (1990) [4].

Kodomillet

Significant differences were noticed in all the yield attributes of kodo millet. The higher length of panicle per plant (10.49 cm), weight of panicle (0.69 g), Weight of grains panicle^{-1} (0.65g) and test weight (4.15 g) was recorded with soybean + kodo millet (4:2) intercropping system, which was significantly superior over sole kodo millet and at par with soybean + kodo millet 3:3 cropping system. Similar result were reported by Sharma and Gupta (2002) [12].

Among the fertilizer levels, application of 100 percent RDF + 5 tons FYM (10.17 cm) recorded higher length of panicle (10.17cm), weight of panicle plant^{-1} (0.67 g), Weight of grains panicle^{-1} (0.66g) and test weight (4.17 g) which was significantly superior over 50 percent RDF + 5 tons FYM and at par with 100 percent RDF. Similar result was reported by Pradhan *et al*. (2014) [10].

None of the interaction was found to be significant for yield parameters of kodo millet

Table 2: Yield attributes of soybean and kodo millet as influenced by different treatments

Treatment	soybean				kodo millet			
	No. of pods	Wt. of pods plant^{-1}	Seed yield plant^{-1}	100 seed Weight	Length of panicle	Wt. of panicle (g)	Wt. of grains panicle^{-1} (g)	Test wt. (g)
A. Cropping system								
C1- Sole soybean	49.5	11.45	7.17	9.61	10.49	0.69	0.65	4.15
C2- soybean + kodo millet (4:2)	45.3	9.63	6.16	8.59	9.98	0.69	0.65	4.01
C3- Soybean + Kodo millet (3:3)	45.3	9.45	6.04	8.51	8.66	0.56	0.59	3.65
SE(m)±	0.95	0.42	0.25	0.29	0.33	0.01	0.02	0.12
CD at 5%	2.85	1.27	0.76	0.88	1.00	0.04	0.05	0.37
B. Fertilizer levels								
N1- 100% RDF	48.2	10.66	6.59	9.32	10.11	0.67	0.64	4.01
N2-100%RDF+ 5 tons FYM	48.2	10.73	6.93	9.33	10.17	0.67	0.66	4.17
N3-50% RDF+5 tons FYM	43.6	9.13	5.85	8.06	8.84	0.61	0.59	3.64
SE(m)±	0.95	0.42	0.25	0.29	0.33	0.01	0.02	0.12
CD at 5%	2.85	1.27	0.76	0.88	1.00	0.04	0.05	0.37
Interaction A× B								
SE(m)±	1.65	0.73	0.44	0.51	0.58	0.02	0.03	0.22
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS

Effect on seed, straw and biological yield

Soybean

As regards cropping system, sole soybean recorded highest seed yield (955 kg ha^{-1}), Straw yield (1230 kg ha^{-1}) which was found to be significantly superior over soybean + kodo millet (4:2) 809 kg ha^{-1} and (3:3) 495 kg ha^{-1}. Maximum biological yield (2189 kg ha^{-1}) was observed due to sole soybean which was highest over intercropped of soybean + kodo millet 4:2 (1898 kg ha^{-1}) and 3:3 (1230 kg ha^{-1}) row proportion. The increase in biological yield (kg ha^{-1}) due to sole soybean was 15.33 percent and 77.97 percent as compared to soybean + kodo millet of 4:2 and 3:3 row proportion.This might be due to maximum yield per plant with average plant population, maximum number of pods per plant, more number of seed per plant and highest test weight obtained with sole soybean. Similar type of results were also reported by Shrivastava *et al*. (2014) [13].

Among the fertilizer levels, 100 percent RDF + 5 tons FYM recorded highest seed yield (797kg), straw yield (1087 kg ha^{-1}) which was significantly superior over 50 percent RDF + 5 tons FYM (696kg) and at par with 100 percent RDF (767 kg). Application of 100 percent RDF + 5 tons FYM recorded increased seed and straw yield by 12.59, 17.89 percent, respectively as over 50 percent RDF + 5 tons FYM. Similarly, 100% RDF + 5 tons FYM recorded significantly maximum biological yield (1858kg ha^{-1}) over 50% RDF + 5 tons FYM (1626 kg ha^{-1}) and at par with 100% RDF (1833 kg ha^{-1}). This might be due to maximum yield per plant with average plant population, maximum number of pods per plant, more number of seed per plant and highest test weight due to higher levels of fertilizer. Similar yield increase with higher fertility level was quoted by Patel *et al*. (1996) [9], and Gaughua *et al*. (2000).

Overall seed yield was lesser as the rainfall during this season was quiet low during all the growth stages of soybean crop. Rainfall at vegetative stage was 226.5 mm and at reproductive stage viz. flowering stage, seed filling stage up to harvest it was 364.3 mm means total rainfall during cropping period was 590.8 mm and overall during *kharif* season was 640mm. Climatic condition adversely affect soybean yield, dry spells at critical growth stages ultimately affected the crop yield. More number of pods per plant were observed but seeds were shrivelled, small in size, test weight was low which affected the seed yield of soybean.

The interaction between cropping system and fertilizer level on seed, straw and biological yield was found to be non-significant.

Kodo millet

As regards cropping system, sole kodo millet recorded highest seed (1408 kgha^{-1}), straw (2747 kgha^{-1})and biological yield (4155 kg ha^{-1}) which was significantly superior over soybean + kodo millet (4:2) and (3:3) row proportion. Seed yield of sole kodo millet over intercropped kodo millet was 65.71 percent more. The seed, straw and biological yield was lower in the intercropping system as compared to sole kodo millet due to less number of rows in the intercropping system. Similar result were reported by Guggari and Kalaghatagi (2005) [6], Ansari *et al*. (2011) [3].

In respect of fertilizer levels, seed, straw and biological yield were found increased significantly with increasing levels of fertilizer from 50 percent RDF + 5 tons FYM to 100 percent RDF+ 5 tons FYM. Application of 100 percent RDF + 5 tons FYM recorded highest seed (935 kg ha^{-1}), straw (1896 kgha^{-1}) and biological yield (2831 kg ha^{-1}) and was significantly superior over 50 percent RDF + 5 tons FYM (841.22 kg ha^{-1}) and comparable with 100 percent RDF. Application of 100 per cent RDF + 5 tons FYM recorded increased seed yield ha^{-1} by 10.02 percent as compared to 50 percent RDF + 5 tons FYM. Similar result was also supported by Pradhan *et al*. (2011) [10].

Soybean seed equivalent yield

Cropping system had significant influenced on soybean seed equivalent yield. Significantly highest soybean seed equivalent yield (1408 kgha^{-1}) was obtained in sole kodo millet over sole soybean and soybean + kodo millet intercropping with 4:2 and 3:3 row proportion.

Economics

Soybean

Cropping system had significant influenced on gross monetary returns, net monetary returns and B: C ratio. gross monetary returns (Rs. 53301 ha^{-1}), net monetary returns (Rs.32197 ha$^{-1)}$ and B:C ratio (2.53) were obtained Similar result was reported by Angadi *et al*. (2004) [2].

Application of fertilizer had significantly influenced the gross monetary returns, net monetary returns and B:C ratio. Highest gross monetary returns of (Rs. 46546 ha^{-1}), were obtained with 100% RDF + 5 tons FYM which was significantly superior over 50% RDF + 5 tons FYM and at par with 100% RDF. Net monetary returns (Rs. 22478 ha^{-1}) and B:C ratio (2.02) by treatment 100 percent RDF, was found significantly superior over 50% RDF+ 5 tons FYM (Rs. 17750 ha^{-1}, and 1.79, respectively) and comparable with 100 percent RDF + 5 tons FYM (Rs. 20069 ha^{-1}, 1.80, respectively). Similar results were reported by Nigade *et al.* (2014) [8].

Interaction was found to be non-significant in respect of seed, straw and biological yield.

Table 3: Grain yield (GY), straw yield (SY), biological yield (BY) and seed yield equivalent (SYE) of soybean and kodo millet as influenced by different treatments

Treatment	Soybean			Kodo millet			Soybean seed equivalent yield (kgha^{-1})
	GY (kgha^{-1})	SY (kgha^{-1})	BY (kgha^{-1})	GY (kgha^{-1})	SY (kgha^{-1})	BY (kgha^{-1})	
A. Cropping system							
C_1- Sole soybean	955	1231	2189	-	-	-	955
C_2- soybean + kodo millet(4:2)	809	1119	1898	482	1104	1586	1288
C_3- Soybean + Kodo millet (3:3)	495	735	1230	807	1608	2415	1302
C_4 - Sole kodo millet	-	-	-	1408	2747	4155	1408
SE(m)±	26.15	39.89	50.70	25.28	45.77	70.11	31.23
CD at 5%	78.40	119.58	152.01	75.80	137.20	210.18	91.59
B. Fertilizer levels							
N_1- 100% RDF	767	1074	1833	922	1848	2770	1281
N_2-100%RDF+ 5 tons FYM	797	1088	1858	935	1896	2831	1295
N_3-50% RDF+5 tons FYM	696	923	1626	841	1716	2557	1138
SE(m)±	26.15	39.89	50.70	25.28	45.77	70.11	27.04
CD at 5%	78.40	119.58	152.01	75.80	137.20	210.18	79.32
Interaction A × B							
SE(m)±	45.30	69.09	87.82	43.79	79.27	121.43	54.09
CD at 5%	NS	NS	NS	NS	NS	NS	NS

The interaction effect between cropping system and fertilizer levels on gross monetary returns, net monetary returns was found to be non-significant.

Kodomillet

Significant influence on gross monetary returns, net monetary returns and B: C ratio was noticed due to different cropping system. Highest gross monetary returns (Rs.53301 ha^{-1}), net monetary returns (Rs.32197 ha$^{-1)}$ and B:C ratio (2.53) was obtained in sole kodo millet over sole soybean and soybean + kodo millet intercropping with 4:2 and 3:3 row proportion. Similar result was reported by Angadi *et al*. (2004) [2].

Table 4: Soybean seed equivalent yield (SCEY), Gross Monetary Returns, Net Monetary Returns and B: C ratio as influenced by different treatments

Treatment	SCEY (kgha^{-1})	GMR (Rs/ha)	NMR (Rs/ha)	Benefit: Cost ratio
A. Cropping system				
C1- Sole soybean	955	31790	5302	1.21
C2- soybean + kodo millet(4:2)	1288	45657	19843	1.77
C3- Soybean + Kodo millet (3:3)	1302	47241	23054	1.96
C_4 - Sole kodo millet	1408	53301	32197	2.53
SE(m)±	31.23	1098.19	1097	0.04
CD at 5%	91.59	3220.89	3219	0.33
B. Fertilizer levels				
N1- 100% RDF	1281	45954	22478	2.02
N2-100%RDF+ 5 tons FYM	1295	46546	20069	1.80
N3-50% RDF+5 tons FYM	1138	40993	17750	1.79
SE(m)±	27.04	951.06	950.67	0.04
CD at 5%	79.32	2789.37	2788.23	0.11
Interaction A × B				
SE(m)±	54.09	1902.12	1901.35	0.08
CD at 5%	NS	NS	NS	NS

The data from Table 4 shows that, highest gross monetary returns (Rs. 46546 ha^{-1}), were obtained by treatment 100% RDF + 5 tons FYM which was significantly superior over 50% RDF + 5 tons FYM and at par with 100% RDF. Net

monetary returns (Rs. 22478 ha^{-1}) and B:C ratio (2.02) were obtained by treatment 100 percent RDF, which was significantly superior over 50% RDF+ 5 tons FYM (Rs. 17750 ha^{-1}, and 1.79 respectively) and at par with 100 percent RDF + 5 tons FYM (Rs. 20069 ha^{-1}, 1.80 respectively). Similar result were reported by Nigade *et al.* (2014) [8].

The interaction effect between cropping system and fertilizer levels on gross monetary returns, net monetary returns was found to be non-significant.

Conclusion

As an intercrop Kodo millet can prove a better intercrop in soybean based intercropping system. Both the proportion of soybean + kodo millet viz. 4:2 and 3:3 were found productive and remunerative. In respect of fertilizer levels, application of 100 per cent RDF + 5 tons FYM proved better in producing highest production and more economic returns.

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