

Supplementary materials

Table S1. Experiment description of all inter- and mono-cropped trials. ‘L’, ‘H’, ‘M’, and ‘N’, respectively denote low, high, moderate and no shade. ‘M’ denotes mono-crop.

Site	Planting dates (seasons)	Shade level	Mean PAR (micro mole m s ⁻¹)	Banana		Bush beans			Climbing bean			Amaranth		
				Plot size (m)	Spacing (m)	Full plot size (m)	Net plot size (m)	Spacing (cm)	Full plot size (m)	Net plot size (m)	Spacing (cm)	Full plot size (m)	Net plot size (m)	Spacing (cm)
Katana 1	September 2014	L	1,267	18 x 8	2 x2	2.5 x 6	1.5 x 5.6	50 x 20	2.5 x 6	1.5 x 5.5	50 x 25	2.5 x 6	1.5 x 5.7	50 x 15
		L	1,463	27 x 8	2x3	2.5 x 6	1.5 x 5.6	50 x 20	2.5 x 6	1.5 x 5.5	50 x 25	2.5 x 6	1.5 x 5.7	50 x 15
		L	1,529	27 x 12	3x3	2.5 x 6	1.5 x 5.6	50 x 20	2.5 x 6	1.5 x 5.5	50 x 25	2.5 x 6	1.5 x 5.7	50 x 15
	March 2015	H	228	18 x 8	2 x2	2.5 x 6	1.5 x 5.6	50 x 20	2.5 x 6	1.5 x 5.5	50 x 25	2.5 x 6	1.5 x 5.7	50 x 15
		H	392	27 x 8	2x3	2.5 x 6	1.5 x 5.6	50 x 20	2.5 x 6	1.5 x 5.5	50 x 25	2.5 x 6	1.5 x 5.7	50 x 15
		H	501	27 x 12	3x3	2.5 x 6	1.5 x 5.6	50 x 20	2.5 x 6	1.5 x 5.5	50 x 25	2.5 x 6	1.5 x 5.7	50 x 15
		N	1,739	26.5 x 19	M	2.5 x 6	1.5 x 5.6	50 x 20	2.5 x 6	1.5 x 5.5	50 x 25	2.5 x 6	1.5 x 5.7	50 x 15
	September 2015	H	168	18 x 8	2 x2	2.5 x 6	1.5 x 5.6	50 x 20	2.5 x 6	1.5 x 5.5	50 x 25	2.5 x 6	1.5 x 5.7	50 x 15
		H	273	27 x 8	2x3	2.5 x 6	1.5 x 5.6	50 x 20	2.5 x 6	1.5 x 5.5	50 x 25	2.5 x 6	1.5 x 5.7	50 x 15
		H	259	27 x 12	3 x3	2.5 x 6	1.5 x 5.6	50 x 20	2.5 x 6	1.5 x 5.5	50 x 25	2.5 x 6	1.5 x 5.7	50 x 15
		N	1,700	26.5 x 19	M	2.5 x 6	1.5 x 5.6	50 x 20	2.5 x 6	1.5 x 5.5	50 x 25	2.5 x 6	1.5 x 5.7	50 x 15
Katana 2	September 2015	H	390	36 x 9	4 x 3	10.5 x 12	9.5 x 11.6	50 x 20	10.5 x 12	9.5 x11.5	50 x 25	10.5 x 12	9.5 x 11.7	50 x 15
		N	1,700	26.5 x 19	M	2.5 x 6	1.5 x 5.6	50 x 20	2.5 x 6	1.5 x 5.5	50 x 25	2.5 x 6	1.5 x 5.7	50 x 15
	March 2016	H	301	36 x 9	4 x 3	10.5 x 12	9.5 x 11.6	50 x 20	10.5 x 12	9.5 x11.5	50 x 25	10.5 x 12	9.5 x 11.7	50 x 15
		N	1,806	26.5 x 19	M	2.5 x 6	1.5 x 5.6	50 x 20	2.5 x 6	1.5 x 5.5	50 x 25	2.5 x 6	1.5 x 5.7	50 x 15
Kavumu	March 2015	M	813	45 x 22	4 x 3	2 x 4	1.5 x 3.6	50 x 20	2 x 4	1.5 x 3.5	50 x 25	2 x 4	1.5 x 3.7	50 x 15
		N	1,898	45 x 22	M	2 x 4	1.5 x 3.6	50 x 20	2 x 4	1.5 x 3.5	50 x 25	2 x 4	1.5 x 3.7	50 x 15
	September 2015	M	640	45 x 22	4 x 3	2 x 4	1.5 x 3.6	50 x 20	2 x 4	1.5 x 3.5	50 x 25	2 x 4	1.5 x 3.7	50 x 15
		N	1,827	45 x 22	M	2 x 4	1.5 x 3.6	50 x 20	2 x 4	1.5 x 3.5	50 x 25	2 x 4	1.5 x 3.7	50 x 15
	March 2016	M	663	45 x 22	4 x 3	2 x 4	1.5 x 3.6	50 x 20	2 x 4	1.5 x 3.5	50 x 25	2 x 4	1.5 x 3.7	50 x 15
		N	1,756	45 x 22	M	2 x 4	1.5 x 3.6	50 x 20	2 x 4	1.5 x 3.5	50 x 25	2 x 4	1.5 x 3.7	50 x 15
		M	601	45 x 22	4 x 3	2 x 4	1.5 x 3.6	50 x 20	2 x 4	1.5 x 3.5	50 x 25	2 x 4	1.5 x 3.7	50 x 15

	September 2016	N	1896	45 x 22	M	2 x 4	1.5 x 3.6	50 x 20	2 x 4	1.5 x 3.5	50 x 25	2 x 4	1.5 x 3.7	50 x 15
	March 2017	H	429	20 x 23	2 x 2	7 x 6	6.6 x 5	50 x 20	NA	NA	50 x 25	NA	NA	50 x 15
		M	779	20 x 23	4 x 4	7 x 6	6.6 x 5	50 x 20	NA	NA	50 x 25	NA	NA	50 x 15
		N	1,749	20 x 23	M	7 x 6	6.6 x 5	50 x 20	NA	NA	50 x 25	NA	NA	50 x 15
INERA- Mulungu 2	September 2017	H	445	20 x 23	2 x 2	7 x 6	6.6 x 5	50 x 20	NA	NA	50 x 25	NA	NA	50 x 15
		M	833	20 x 23	4 x 4	7 x 6	6.6 x 5	50 x 20	NA	NA	50 x 25	NA	NA	50 x 15
		N	1,795	20 x 23	M	7 x 6	6.6 x 5	50 x 20	NA	NA	50 x 25	NA	NA	50 x 15
	March 2018	M	694	20 x 23	2 x 2	7 x 6	6.6 x 5	50 x 20	NA	NA	50 x 25	NA	NA	50 x 15
		M	994	20 x 23	4 x 4	7 x 6	6.6 x 5		NA	NA	50 x 25	NA	NA	50 x 15
		N	1,799	20 x 23	M	7 x 6	6.6 x 5	50 x 20	NA	NA	50 x 25	NA	NA	50 x 15
INERA- Mulungu 1	March 2016	L	1,092	63 x 12	4 x 3	12 x 6	11.6 x 5	50 x 20	12 x 6	11.5 x 5	50 x 25	12 x 6	11.5 x 7	50 x 15
	September 2016	H	415	63 x 12	4 x 3	12 x 6	11.6 x 5	50 x 20	12 x 6	11.5 x 5	50 x 25	12 x 6	11.5 x 7	50 x 15

Table S2. The regression (R^2) values between Photosynthetically Active Radiation (PAR) with i) grain yields and ii) biomass yields of bush and climbing beans.

Site/ experiment	Cropping season	Planting density	Grain yield		Biomass yield	
			R^2 (Fpr)		R^2 (Fpr)	
			Bush bean	Climbing bean	Bush bean	Climbing bean
Katana trial 1	Sept. 2014	2x2, 2x3, 3x3m; no monocrop	0.18 (0.650)	0.38 (0.310)	0.07 (0.865)	0.12 (0.759)
	Feb. 2015	2x2, 2x3, 3x3m; with monocrop	0.53 (0.078)	0.63 (0.030)	0.79 (0.002)	0.54 (0.071)
	Sept. 2015	2x2, 2x3, 3x3m; with monocrop	0.98 (0.000)	0.94 (0.000)	0.96 (0.000)	0.96 (0.000)
	All seasons	2x2m across seasons 1, 2 and 3; no monocrop	0.67 (0.050)	0.92 (0.000)	0.83 (0.006)	0.81 (0.008)
	All seasons	2x3m across seasons 1, 2 and 3; no monocrop	0.79 (0.010)	0.84 (0.005)	0.81 (0.008)	0.44 (0.238)
	All seasons	3x3m across seasons 1, 2 and 3; no monocrop	0.94 (0.000)	0.93 (0.000)	0.82 (0.007)	0.41 (0.264)
Katana trial 2 (mixed plot)	All seasons	3x4m across seasons 1 and 2; no monocrop	0.68 (0.140)	0.60 (0.290)	0.94(0.006)	0.50 (0.391)
Kavumu	All seasons	3x4m across seasons 1, 2, 3, and 4; with monocrop	0.18 (0.320)	0.27 (0.150)	0.39 (0.029)	0.28 (0.138)
Mulungu	March 2017	2x2m, 4x4m, with monocrop	0.79 (0.010)	NA	0.91 (0.000)	NA
	Sept. 2017	2x2m, 4x4m, with monocrop	0.92 (0.004)	NA	0.78 (0.012)	NA
	March 2018	2x2m, 4x4m, with monocrop	0.90 (0.001)	NA	0.84 (0.005)	NA
	All seasons	2x2m across seasons 1, 2, 3; with monocrop	0.64 (0.004)	NA	0.49 (0.40)	NA
	All seasons	4x4m across seasons 1, 2, 3 and monocrop	0.5 (0.030)	NA	0.21 (0.413)	NA
	All seasons	3x4m season 1, 3x4m season 2; no monocrop	0.69 (0.13)	0.96 (0.002)	0.65 (0.163)	0.84 (0.036)

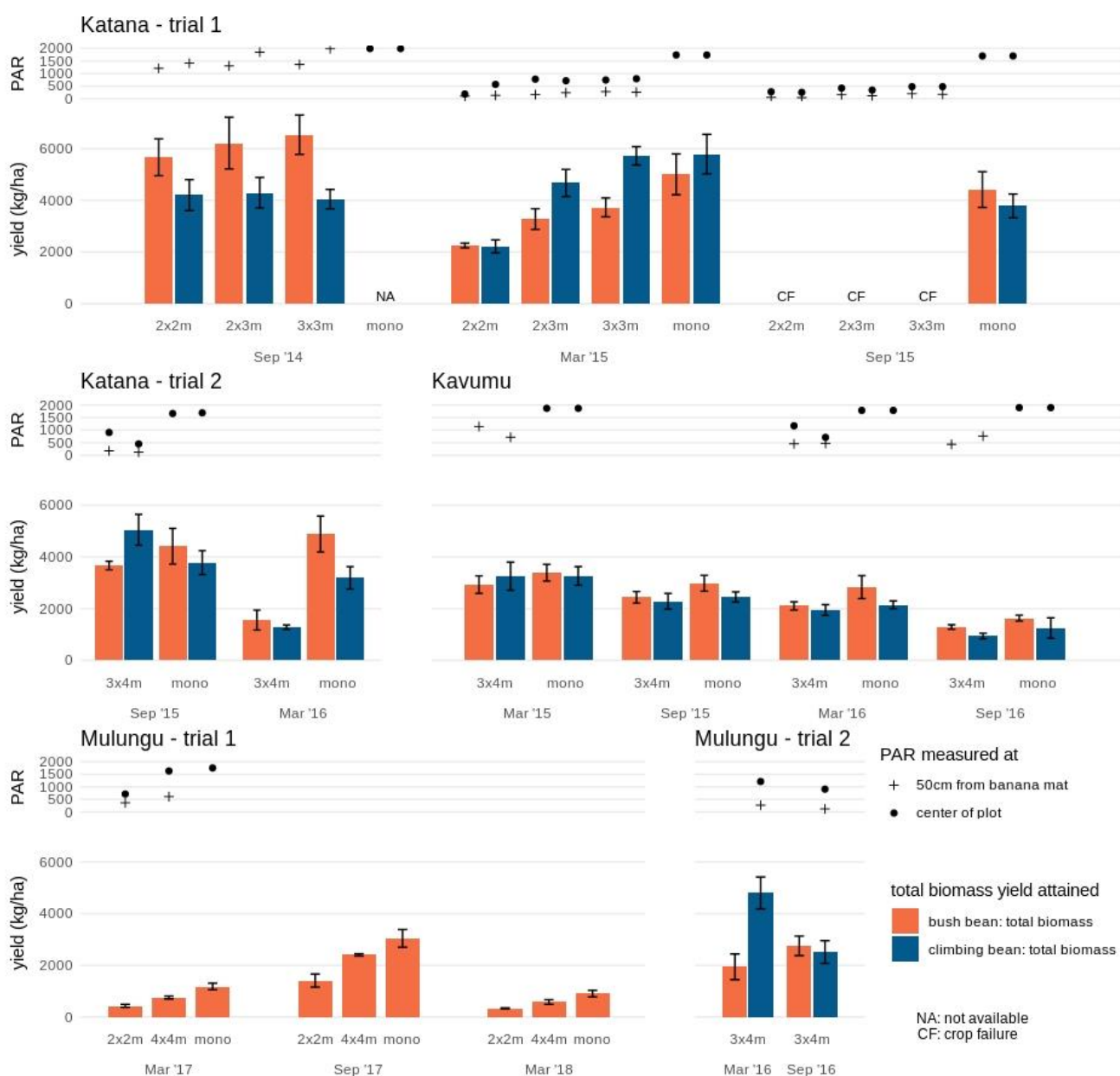


Figure S1. Crop performance of bush bean and climbing bean in various intercrop formations and monocrops at the study sites Katana, Kavumu and Mulungu. The total aboveground biomass yield represents the sum of the grain and non-edible aboveground yield, and is indicated separately for bush bean (orange) and climbing bean (blue) at each intercrop formation and cropping season. At Katana, the crop failure (CF) in September 2015 is indicated. The annual crop in monocrop formation is not assessed (NA) at Katana in September 2014 and not available in trial 2 at Mulungu. Photosynthetic active radiation (PAR) measured at the center of the plot (full circle) and 50cm from the banana mat (cross) is indicated for each annual intercrop and monocrop. Note that during some stages of the experimental trial PAR measurements are not available due to temporary equipment defects.

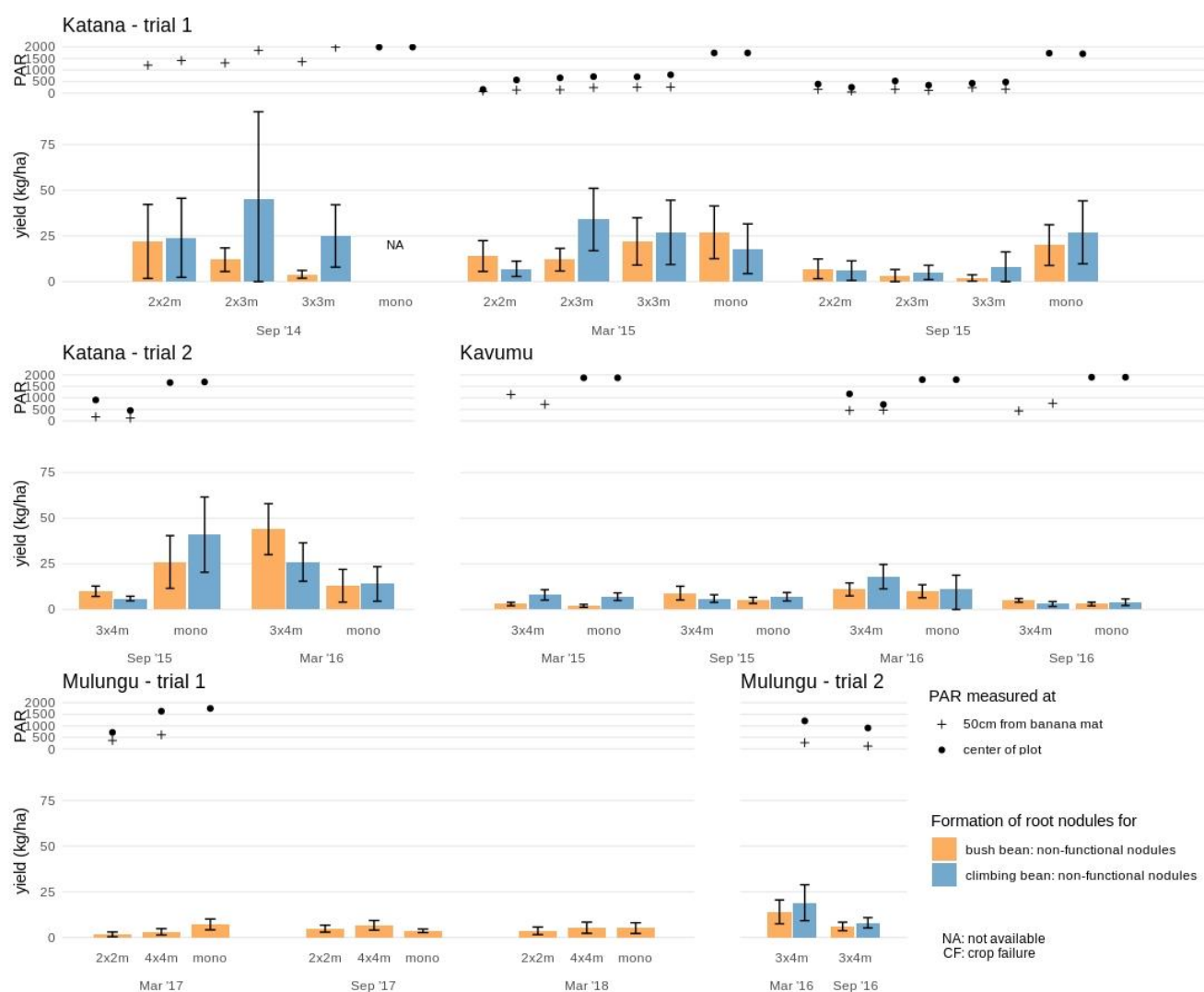


Figure S2. Root nodule formation of bush bean and climbing bean in various intercrop formations and monocrops at the study sites Katana, Kavumu and Mulungu. Non-functional root nodules are presented for bush bean (orange) and climbing bean (blue) at each intercrop formation and cropping season. The annual crop in monocrop formation is not assessed (NA) at Katana in September 2014 and not available in trial 2 at Mulungu. Photosynthetic active radiation (PAR) measured at the center of the plot (full circle) and 50cm from the banana mat (cross) is indicated for each annual intercrop and monocrop. Note that during some stages of the experimental trial PAR measurements are not available due to temporary equipment defects.

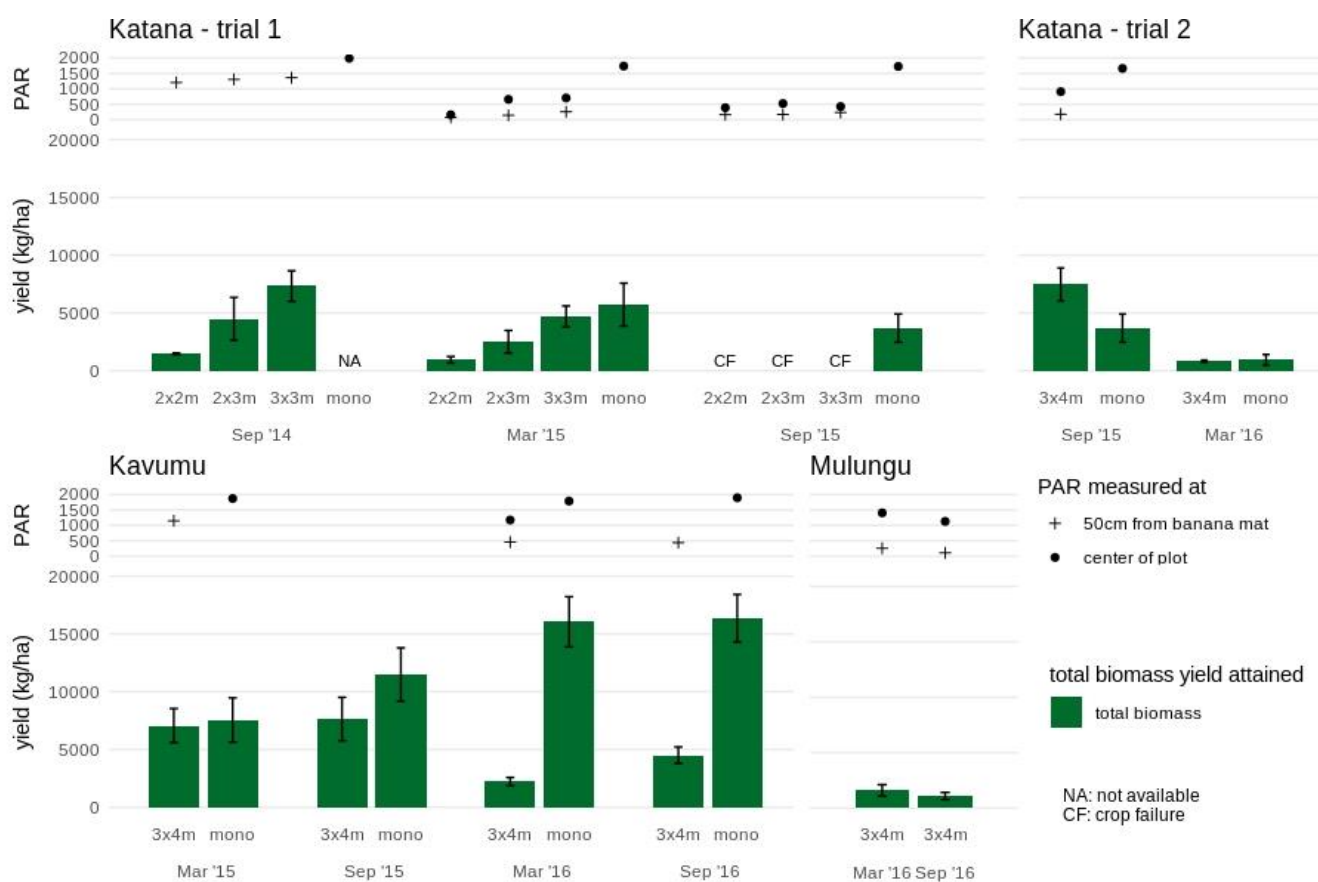


Figure S3. Crop performance of amaranth in various intercrop formations and monocrops at the study sites Katana, Kavumu and Mulungu. The total aboveground biomass yield represents the sum of the edible and non-edible aboveground biomass. All yields are indicated for each intercrop formation and cropping season. At Katana, the crop failure (CF) in September 2015 is indicated. The annual crop in monocrop formation is not assessed (NA) at Katana in September 2014 and not available in trial 2 at Mulungu. Photosynthetic active radiation (PAR) measured at the center of the plot (full circle) and 50cm from the banana mat (cross) is indicated for each annual intercrop and monocrop. Note that during some stages of the experimental trial PAR measurements are not available due to temporary equipment defects.