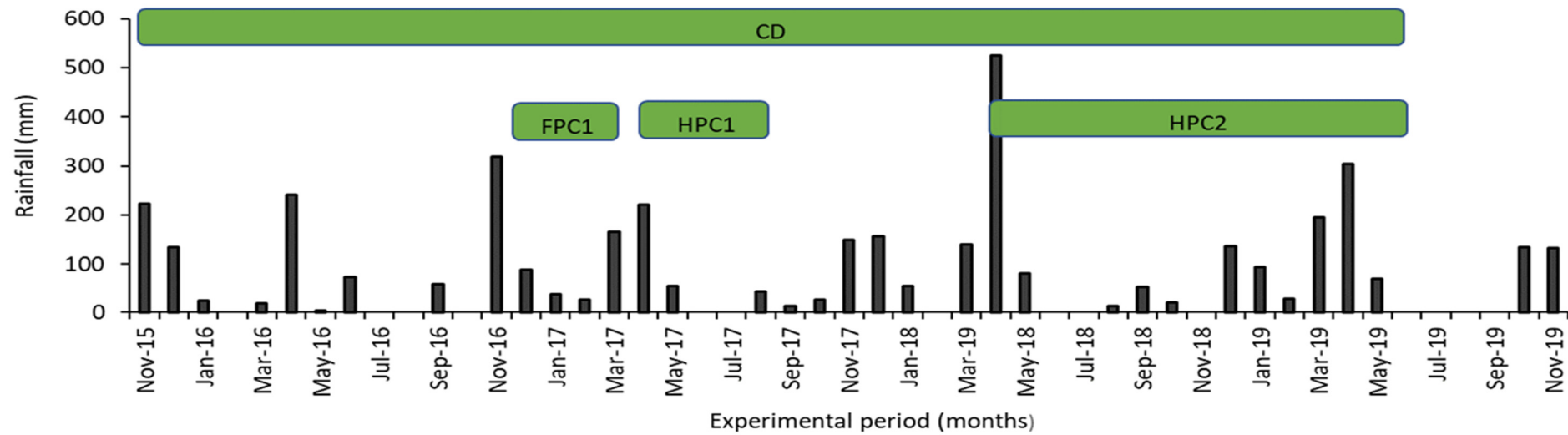
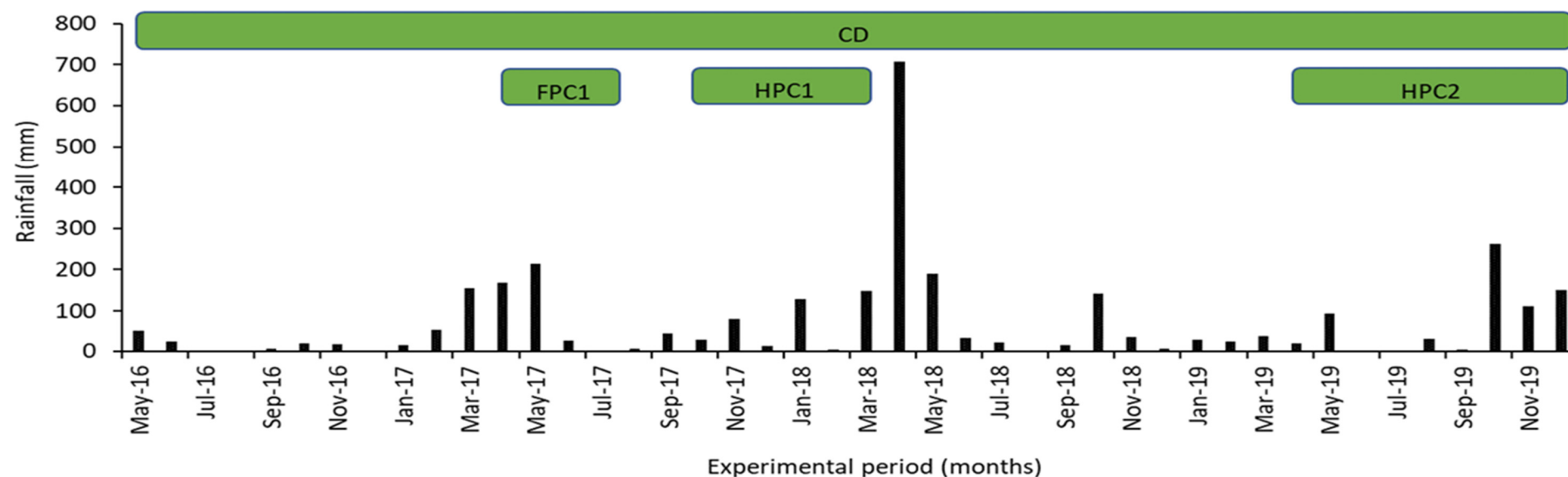


**Figure S1.** Monthly rainfall, crop duration, and harvesting periods during the experimental period at the Lyamungo research site located on the southeast slopes of Mount Kilimanjaro. CD refers to the crop duration of both cycles one and two; FPC1 flowering period cycle one; HPC1 harvesting period cycle one; HPC2 harvesting period cycle two.



**Figure S2.** Monthly rainfall, crop duration, and harvesting periods during the experimental period at the Tarakea research site located on the northeast slopes of Mount Kilimanjaro. CD refers to the crop duration of both cycles one and two; FPC1 flowering period cycle one; HPC1 harvesting period cycle one; HPC2 harvesting period cycle two.



**Figure S3.** Monthly rainfall, crop duration, and harvesting periods during the experimental period at the Tengeru research site located on the southeast slopes of Mount Meru. CD refers to the crop duration of both cycles one and two; FPC1 flowering period cycle one; HPC1 harvesting period cycle one; HPC2 harvesting period cycle two.

**Table S1.** Common bean haulms produced in situ in the banana-bean intercrop treatment plots in each site and nutrients supplied by the haulms ( $\text{kg ha}^{-1} \text{ year}^{-1}$ ).

Experimental sites	Common bean haulms yield ( $\text{kg ha}^{-1} \text{ year}^{-1}$ )	Nutrients supplied by common bean haulms ( $\text{kg ha}^{-1} \text{ year}^{-1}$ )		
		N	P	K
Tarakea	1,666.0	52.0	5.0	40.0
Lyamungo	1,832.0	57.0	5.5	44.0
Tengeru	1,499.0	46.7	4.5	36.0
Average	1,666.0	51.9	5.0	40.0

**Key:** Urea—46 % N, MOP—60 %  $\text{K}_2\text{O}$ , TSP—46 %  $\text{P}_2\text{O}_5$ .

**Table S2.** Fertilization treatments, nutrient sources, and application rates used in the field experiments.

Fertilization treatments	Cattle manure & haulms (kg ha <sup>-1</sup> year <sup>-1</sup> )		Nutrients supplied by manure & haulms (kg ha <sup>-1</sup> year <sup>-1</sup> )			Nutrients supplied by mineral fertilizer (kg ha <sup>-1</sup> year <sup>-1</sup> )		
	Manure	Haulms	N	P	K	N	P (P <sub>2</sub> O <sub>5</sub> )	K (K <sub>2</sub> O)
T1—no N (control)	0.0	0.0	0.0	0.0	0.0	0.0	33.5 (76.7)	459.8 (556.4)
T2—76.7 kg N (urea)	0.0	0.0	0.0	0.0	0.0	76.7	33.5 (76.7)	459.8 (556.4)
T3—153.4 kg N (urea)	0.0	0.0	0.0	0.0	0.0	153.4	33.5 (76.7)	459.8 (556.4)
T4—230 kg N (urea)	0.0	0.0	0.0	0.0	0.0	230.0	33.5 (76.7)	459.8 (556.4)
T5—76.7 kg N (urea) + 76.7 kg N (cattle manure)	38,318.0	0.0	76.7	115	459.8	76.7	0.0	0.0
T6—153.4 kg N (cattle manure)	76,636.0	0.0	153.4	230	919.6	0.0	0.0	0.0
T7—76.7 kg N (urea) + 52 kg (bean haulms)	0.0	1,666.0	51.9	5.0	40.0	76.7	33.5 (76.7)	459.8 (556.4)
T8—52 kg N (bean haulms)	0.0	1,666.0	51.9	5.0	40.0	0.0	33.5 (76.7)	459.8 (556.4)

**Key:** Urea—46 % N, MOP—60 % K<sub>2</sub>O, TSP—46 % P<sub>2</sub>O<sub>5</sub>.

**Table S3.** Mineral nutrient dose (g mat<sup>-1</sup> year<sup>-1</sup>) in the respective fertilization treatments, annual fertilizer budget, and application time during rainy seasons of each year.

Fertilization treatments	Nutrient dose (g mat <sup>-1</sup> year <sup>-1</sup> )			Fertilizer budget and application time during rainy seasons								
				The onset of short rains (g mat <sup>-1</sup> )			The onset of long rains (g mat <sup>-1</sup> )			End of long rains (g mat <sup>-1</sup> )		
	N	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O	Urea	TSP	MOP	Urea	TSP	MOP	Urea	TSP	MOP
T1—no N (control)	0.0	46.0	334.0	0.0	100.0	139.2	0.0	0.0	278.3	0.0	0.0	139.2
T2—76.7 kg N (urea)	46.0	46.0	334.0	25.0	100.0	139.2	50.0	0.0	278.3	25.0	0.0	139.2
T3—153.4 kg N (urea)	92.0	46.0	334.0	50.0	100.0	139.2	100.0	0.0	278.3	50.0	0.0	139.2
T4—230 kg N (urea)	138.0	46.0	334.0	75.0	100.0	139.2	150.0	0.0	278.3	75.0	0.0	139.2
T5—76.7 kg N (urea) + 76.7 kg N (cattle manure)	46.0	0.0	0.0	25.0	0.0	0.0	25.0	0.0	0.0	50.0	0.0	0.0
T6—153.4 kg N (cattle manure)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T7—76.7 kg N (urea) + 52 kg (bean haulms)	46.0	46.0	334.0	25.0	100.0	139.2	50.0	0.0	278.3	25.0	0.0	139.2
T8—52 kg N (bean haulms)	0.0	46.0	334.0	0.0	100.0	139.2	0.0	0.0	278.3	0.0	0.0	139.2

**Key:** Urea—46 % N, MOP—60 % K<sub>2</sub>O, TSP—46 % P<sub>2</sub>O<sub>5</sub>.

**Table S4.** Variable costs (US\$ ha<sup>-1</sup> year<sup>-1</sup>) involved in each fertilization treatment in the Tarakea research field located on the northeast slopes of Mount Kilimanjaro in the central-northern highlands, Tanzania.

Fertilization treatments	Inputs						Labor costs			
	Bean seed	Cattle manure	Urea	TSP	MOP	Rhizobium inoculant	Bean planting	Fertilizer application	Weeding	Bean harvesting
T1—no N (control)	0.0	0.0	0.0	195.0	584.0	0.0	0.0	61.0	173.0	0.0
T2—76.7 kg N (urea)	0.0	0.0	156.0	195.0	584.0	0.0	0.0	69.0	173.0	0.0
T3—153.4 kg N (urea)	0.0	0.0	312.0	195.0	584.0	0.0	0.0	69.0	173.0	0.0
T4—230 kg N (urea)	0.0	0.0	468.0	195.0	584.0	0.0	0.0	69.0	173.0	0.0
T5—76.7 kg N (urea) + 76.7 kg N (cattle manure)	0.0	1494.0	156.0	0.0	0.0	0.0	0.0	204.0	173.0	0.0
T6—153.4 kg N (cattle manure)	0.0	2986.0	0.0	0.0	0.0	0.0	0.0	277.0	173.0	0.0
T7—76.7 kg N (urea) + 52 kg N (bean haulms)	130.0	0.0	156.0	255.0	706.0	42.0	173.0	86.0	260.0	173.0
T8—52 kg N (bean haulms)	130.0	0.0	0.0	255.0	706.0	42.0	173.0	86.0	260.0	173.0

**Table S5.** Variable costs (US\$ ha<sup>-1</sup> year<sup>-1</sup>) involved in each fertilization treatment in the Lyamungo research field located on the southeast slopes of Mount Kilimanjaro in the central-northern highlands, Tanzania.

Fertilization treatments	Inputs						Labor costs			
	Bean seed	Cattle manure	Urea	TSP	MOP	<i>Rhizobium</i> inoculant	Bean planting	Fertilizer application	Weeding	Bean harvesting
T1—no N (control)	0.0	0.0	0.0	180.0	541.0	0.0	0.0	42.0	121.0	0.0
T2—76.7 kg N (urea)	0.0	0.0	144.0	180.0	541.0	0.0	0.0	42.0	121.0	0.0
T3—153.4 kg N (urea)	0.0	0.0	288.0	180.0	541.0	0.0	0.0	42.0	121.0	0.0
T4—230 kg N (urea)	0.0	0.0	433.0	180.0	541.0	0.0	0.0	42.0	121.0	0.0
T5—76.7 kg N (urea) + 76.7 kg N (cattle manure)	0.0	1371.0	144.0	0.0	0.0	0.0	0.0	204.0	121.0	0.0
T6—153.4 kg N (cattle manure)	0.0	2742.0	0.0	0.0	0.0	0.0	0.0	277.0	121.0	0.0
T7—76.7 kg N (urea) + 57 kg N (bean haulms)	130.0	0.0	144.0	236.0	652.0	42.0	121.0	56.0	182.0	121.0
T8—57 kg N (bean haulms)	130.0	0.0	0.0	236.0	652.0	42.0	121.0	56.0	182.0	121.0

**Table S6.** Variable costs (US\$ ha<sup>-1</sup> year<sup>-1</sup>) involved in each fertilization treatment in the Tengeru research field located on the southeast slopes of Mount Meru in the central-northern highlands, Tanzania.

Fertilization treatments	Inputs						Labor costs				
	Bean seed	Cattle manure	Urea	TSP	MOP	<i>Rhizobium</i> inoculant	Bean planting	Fertilizer application	Weeding	Bean harvesting	
T1—no N (control)	0.0	0.0	0.0	180.0	541.0	0.0	0.0	42.0	121.0	0.0	
T2—76.7 kg N (urea)	0.0	0.0	144.0	180.0	541.0	0.0	0.0	42.0	121.0	0.0	
T3—153.4 kg N (urea)	0.0	0.0	288.0	180.0	541.0	0.0	0.0	42.0	121.0	0.0	
T4—230 kg N (urea)	0.0	0.0	433.0	180.0	541.0	0.0	0.0	42.0	121.0	0.0	
T5—76.7 kg N (urea) + 767 kg N (cattle manure)	0.0	1371.0	144.0	0.0	0.0	0.0	0.0	204.0	121.0	0.0	
T6—153.4 kg N (cattle manure)	0.0	2742.0	0.0	0.0	0.0	0.0	0.0	277.0	121.0	0.0	
T7—76.7 kg N (urea) + 46.7 kg N (bean haulms)	130.0	0.0	144.0	236.0	652.0	42.0	121.0	56.0	182.0	121.0	
T8—46.7 kg N (bean haulms)	130.0	0.0	0.0	236.0	652.0	42.0	121.0	56.0	182.0	121.0	