Use of a Nitrogen Balance to Assess Nitrogen Dynamics in Dryland Organic and Conventional Cropping Systems

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Introduction

Achieving adequate soil nitrogen (N) levels for competitive grain production is one of the primary challenges encountered by organic growers. Animal manure compost and green manures are common sources of nitrogen in organic cropping systems; however, nitrogen from these sources is released slowly over time and contribution to the available nitrogen pool is unclear. Several studies have found that leguminous green manures do not meet subsequent cereal crop N requirements[1,2]; however, others report winter wheat yields of 5.2 to 6.0 t ha^{-1} following a green manure crop[3]. In the dryland area of the inland Pacific Northwest, with an annual average rainfall of less than 600 mm (24 in.), legume biomass production is low and there is question as to whether green manure crops can accumulate enough biomass to contribute to the soil-N pool.

Nitrogen budgets are a tool to track the movement of N through a cropping system. Constructing an N budget enables comparison of the amount of N available for crops to utilize between cropping systems, and is a tactic commonly used to study N dynamics[4,5]. The N contribution by green manure crops will be compared to that of poultry manure in organic systems. Nitrogen dynamics will also be compared between organic and conventional management.

Materials and Methods

- The study was initiated near Pullman, WA in 2008 in a randomized, complete block design. Data was collected from 2009 through 2013.

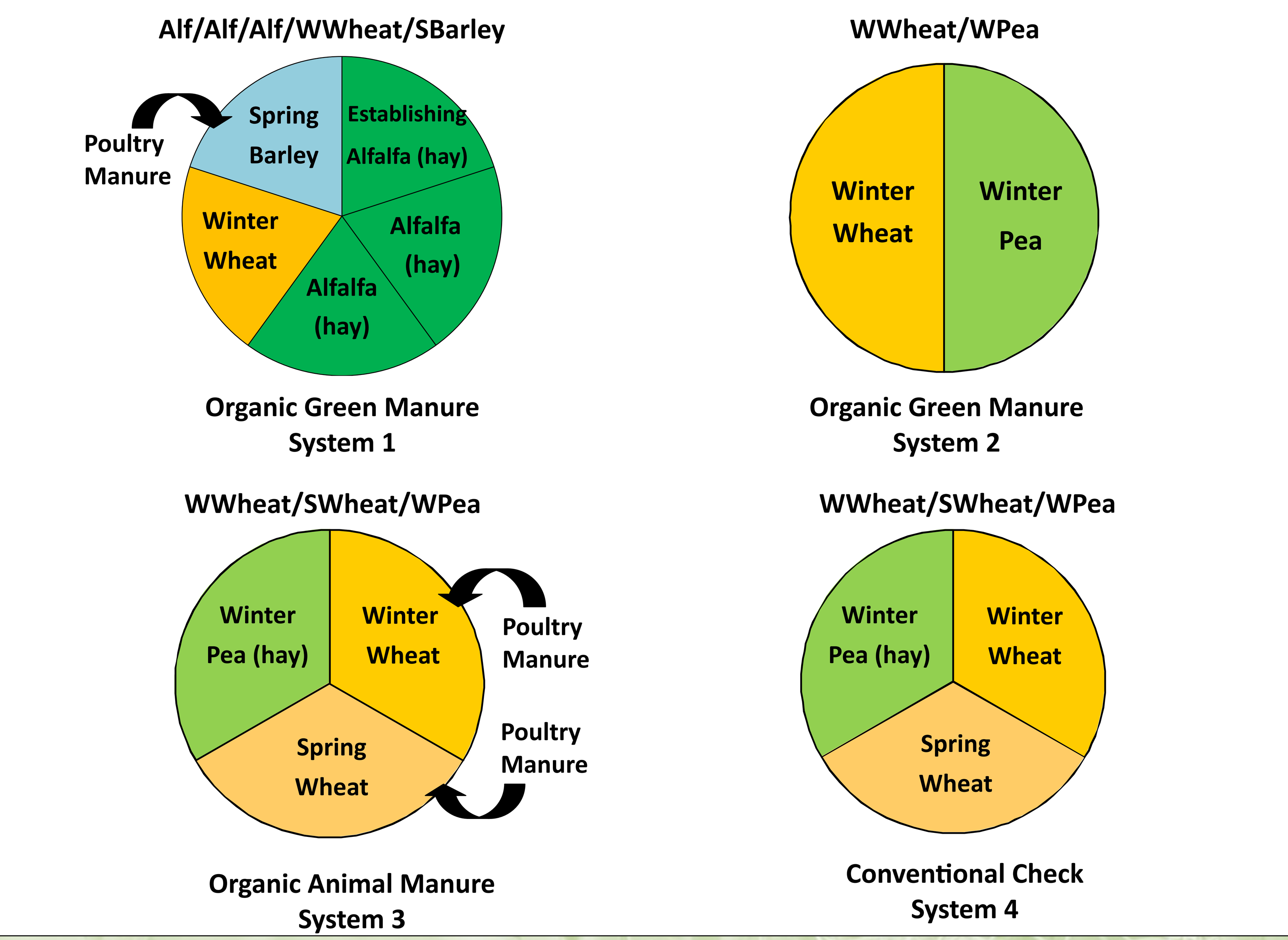

Figure 1. N balances were calculated in each of the cropping systems shown above. Each section of the circle represents one year of the rotation.

$$\text{Net N balance} = \underbrace{[(N_{Fertilizer} + N_{Plant\ Residue} + N_{Soil\ Post\text{-}Harvest}) - N_{Soil\ Pre\text{-}Plant}]}_{\text{Inputs}} - \underbrace{N_{Crop\ Exported}}_{\text{Output}}$$

Figure 2. Net N balance was calculated annually by subtracting the harvest outputs from all fertilizer, biomass residue, and residual soil N levels (inputs).

- N content (%N) was determined using a dry combustion auto analyzer (TruSpec CN Determinator; LECO Corporation St. Joseph, MI) on the following parts:
  - Grain
  - Straw
  - Green Manure biomass
  - Weeds

Results and Discussion

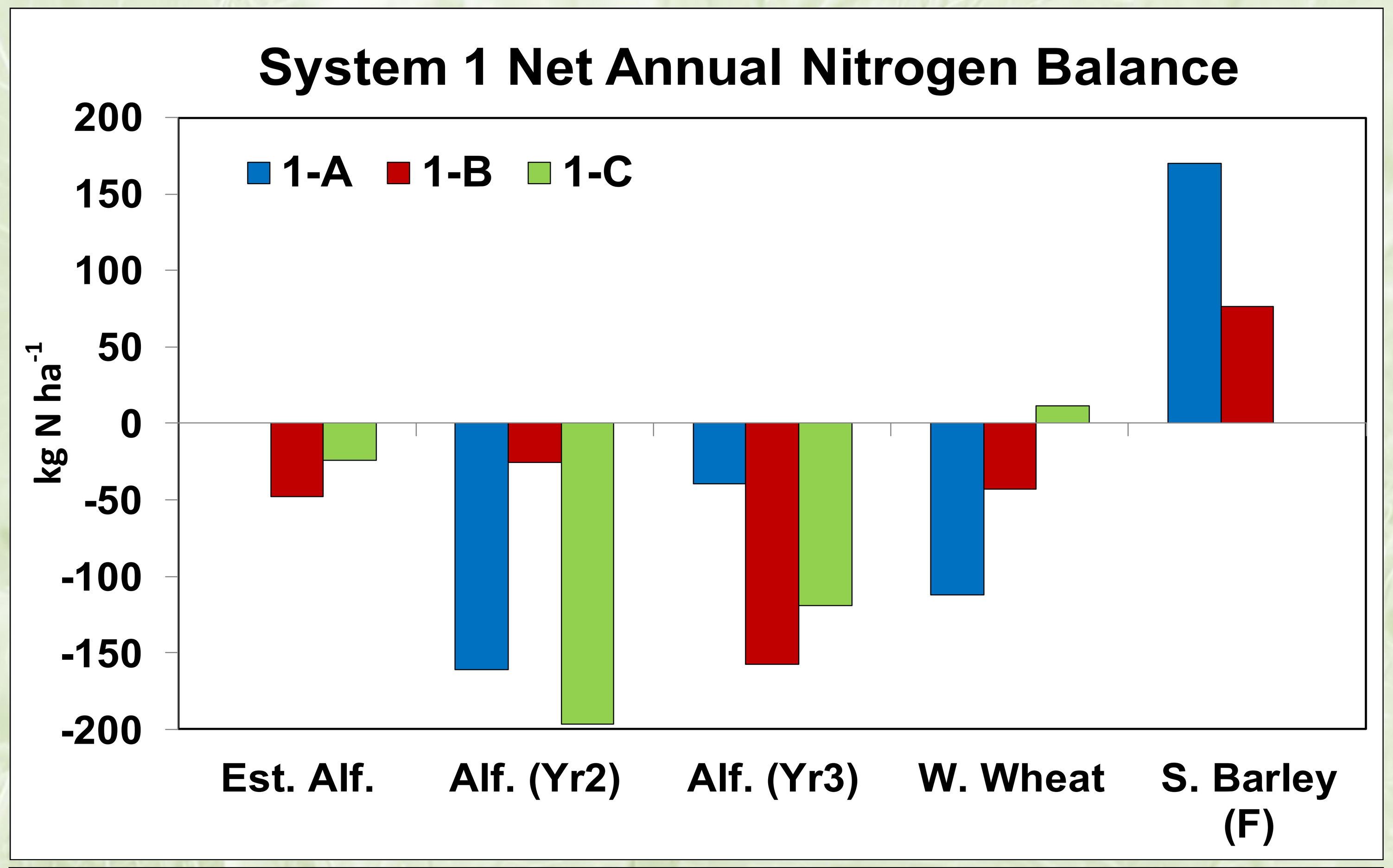

Figure 3. The net annual N balances shown are the average of 5 reps per year. The rotation was replicated 3 times (rotation reps are depicted here as 1-A, 1-B, and 1-C), beginning with different crops. F = received 2400 kg ha^{-1} poultry manure

- Following 3 years of alfalfa, residual inorganic soil-N values measured post-harvest were between 25 and 100 kg ha^{-1}.
- Second- and third-year alfalfa yielded between 1.75 and 3.5 t ha^{-1}, resulting in the export of 30 to 165 kg N ha^{-1} through biomass removal (average annual N export of 90 kg ha^{-1}).

It's All About Winter Wheat Yields

	Grain Yield (kg ha^{-1})				
Year	System 1	System 3	System 4	System 5	County Avg.
2009	—	1290	5500	3740	4740
2010	—	3930	5410	3950	5580
2011	4250	2890	—	—	6050
2012	3690	3730	6450	6170	5580
2013	2050	1340	5280	4560	5710

Figure 5. Grain was harvested with a Kincaid combine. County averages shown are winter wheat yields from Whitman County in eastern Washington.

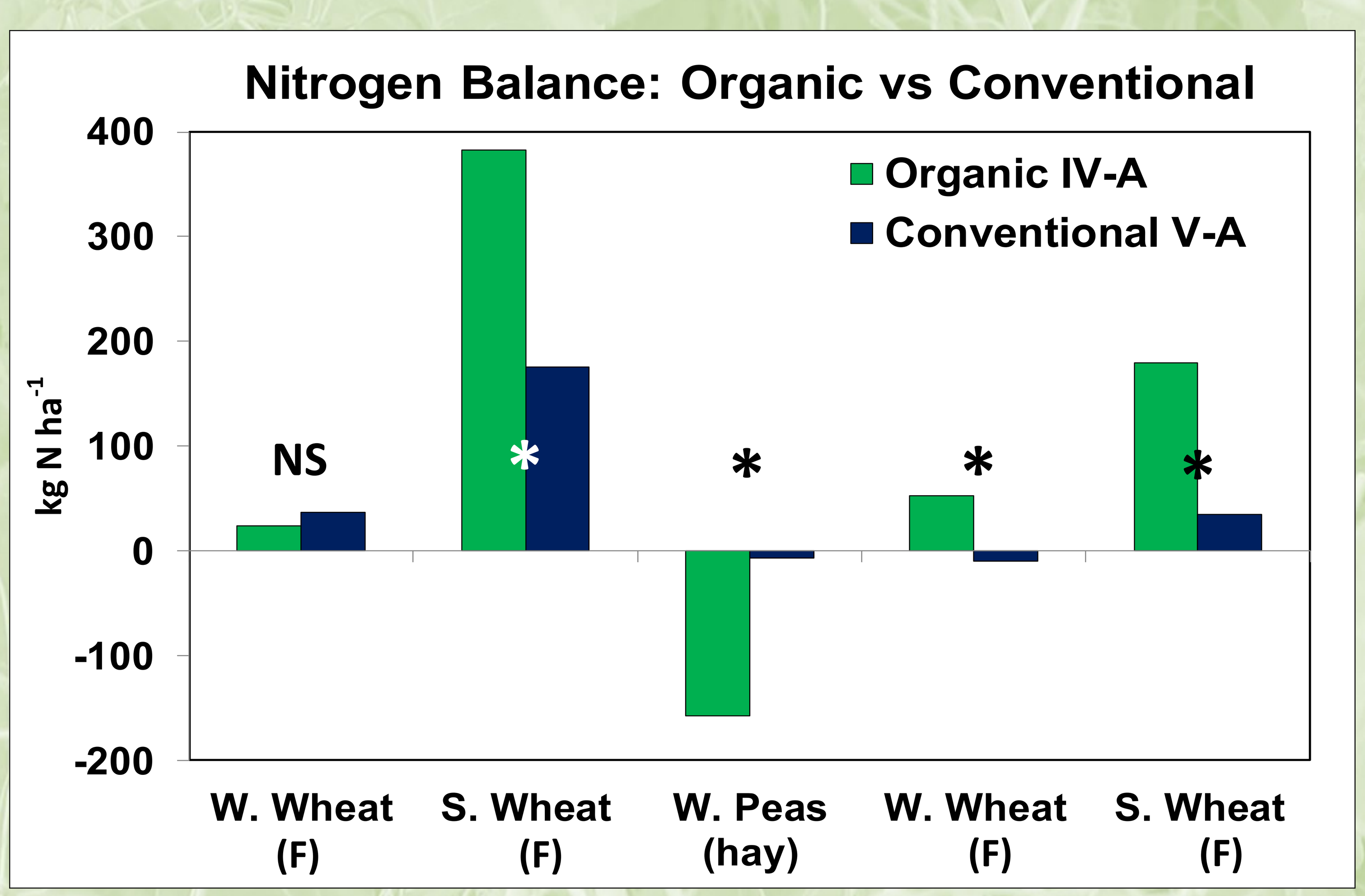

Figure 6. The net annual N balances shown are the average of 5 reps per year. The rotation was replicated 2 times, but only rep *A* is shown here. F = received poultry manure; w. wheat received 4300 kg ha^{-1} and s. wheat received 4800 kg ha^{-1}. System 5 was fertilized with urea in the grain phases, at a rate of 110 kg N ha^{-1}.

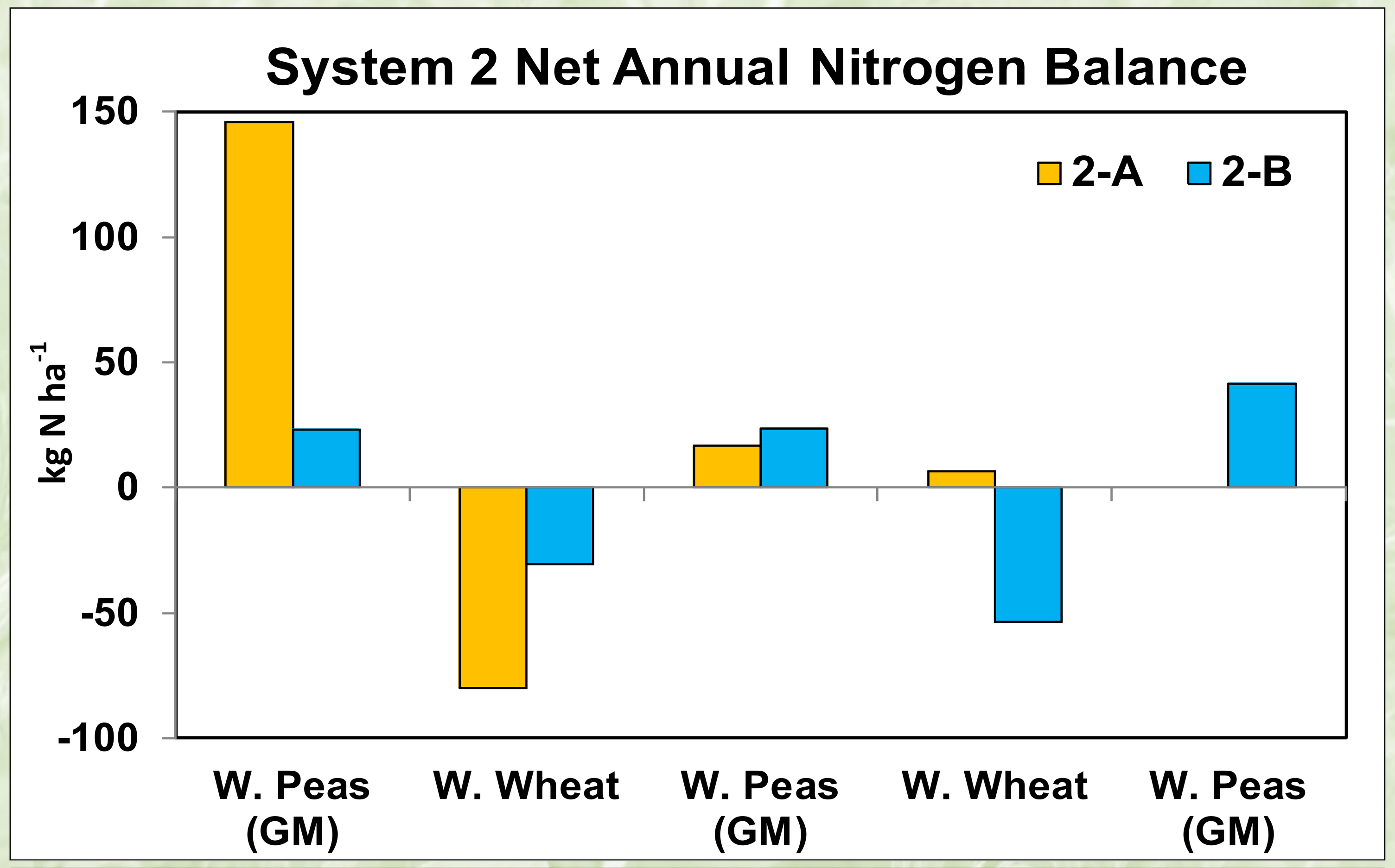

Figure 4. The net annual N balances shown are the average of 5 reps per year. The rotation was replicated 2 times (rotation reps are depicted here as 2-A and 2-B, with a staggered start. No manure was applied to this system.

- Winter Peas, on average, resulted in a positive net N balance of 60 kg N ha^{-1}.
- Net N value from w. peas is still insufficient for acceptable winter wheat yields, as demonstrated by System 2 yielding the lowest of the 4 systems.

Conclusions

- In years where alfalfa biomass was high, the N content of the alfalfa was great enough to support high-yielding wheat, had the biomass been left as green manure. However, alfalfa hay resulted in revenue between $400 and $750 per hectare, making it a difficult economic decision to leave in the field as green manure.
- Alfalfa is more drought-tolerant and accumulates more biomass than winter peas, making it the superior legume in a dryland region; however, yields following hayed alfalfa (Figure 5) are still significantly lower than grain fertilized with poultry manure.
- In dryland regions, alfalfa is one of few legumes that can accumulate large amounts of biomass (and thereby N) with little summer moisture; however, to derive N benefits from alfalfa, hay removal must be minimized.
- Two years of manure addition build a considerable store of residual N, as evidenced in System 3 by large, positive net N values at the end of the spring wheat phase.
- ORGANIC vs. CONVENTIONAL N BALANCE: In organic System 3, N surpluses and deficits were greater in magnitude, compared to its conventional counterpart (where net N generally stayed close to 0).

Acknowledgements

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Citations

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