Integrated Orchard Management

Research on managing an 80 year old Mango Orchard

2022-2024

Project Report April 2024

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Outline

1. Name of the project: Integrated Orchard Management

2. Name of the project holder(s): Anshul Aggarwal

3. Project team: AuroOrchard team

4. Amount received in rupees from SDZ: Rs. 3,52,477

5. Year in which grant received: 2021

6. Amount(s) received from other donors: Rs. 0

7. Aims & objectives of project:

- To convert the space of Mango orchards (about 10 acres) into a poly orchard suitable for rotational grazing by cows.
- To enhance the health of the soil in this area through regular green manuring and intensive grazing
- To increase the capacity of the farm to produce more fruits (like Avocado, Jackfruit, Soursop and some others), for which there is a great demand in the community. This will help build resilience through diversity and financial security for the farm.
- To monitor and optimise the use of water in the Mango Orchard by adding more trees and green manure and fodder crops
- To set up a sustainable free range country poultry in this area which can help the farm to gradually transition from the current system of poultry management.
- To explore if planned intensive grazing by cows and free range poultry can minimise needs for tilling in the area and help move towards a no-till integrated poly orchard.
- To experiment with crop crimping/brush-cutting as an alternative to tilling.

Project Summary

S.no.	Planned goals	
3.	New planting	A lot of new trees have been planted within the orchard. We are now reviewing which plants are doing better than others. A second planting was done during the 2023 summer monsoon. However, we realise that this method is not very effective till we dont invest in microirrigation. So, we have decided to focus on a small part of the orchard where we are now planting more mango trees and adding microirrigation.
4.	Irrigation set up and water metre installation.	The distribution line from the Mango Orchard borewell has been connected to reach the entire Mango Orchard and serve other areas of the farm. This gives us resilience in case our other borewells are not working. A water meter has also been installed on this borewell to measure the amount of water being used. The next step is to extend the system through microirrigation to different parts of the orchard.
5.	Zoning and mapping	We have divided the mango orchard into manageable zones and mapped the areas with the existing and newly planted trees. This has really helped in planning the work in the orchard.
6.	Green manure/ Alternate ways of managing orchard floor	We managed to not plough the orchard this year and instead deal with the weeds/brush by brush cutting. This was a very interesting experience and makes us confident that this can be done. We are looking at ways of making this more efficient and cost effective. We are also looking at if green manuring is a good strategy for the orchard. In the long term though, brush cutting is not a good solution as it is very expensive. We have concluded that light discing (using a tractor) is much more efficient after the monsoon season. This is very shallow ploughing using discs that cut the biomass into the soil adding biomass to it while causing minimal disturbance.
7.	Pruning & Grafting	We have started pruning some Mango trees to create space for coffee and other trees. Some of the wild and undesirable varieties of mango trees have been pruned back to experiment with grafting. Grafts of two desired varieties were prepared and grafted onto the wild trees. We have had 100% success with the grafts and these trees will start yielding in 3 years. This year, our goal is to graft another 20 trees. We should be able to transform the entire orchard in about 5 years with increased yields of the desired varieties starting from 2027.
8.	Integrated grazing by cows	Since the cows have other spaces available on the farm, this has not been the priority. The cows are using one zone of the orchard but we are not actively working on this element of the research

		yet. This part of the project was put on hold as we reduced our cow herd significantly.
9.	Poultry of indigenous birds	After some initial trials, we concluded that a poultry flock of indigenous birds is not optimum to cater to the egg demand of Auroville. We have been experimenting with a Hyline Brown variety of birds that is a cross between indigenous birds and high production varieties. These birds are much better suited to the context of free ranging than the existing white birds we have. Through the support of this fund, we have been able to build a new coop for these birds to keep the flocks in rotation.
10.	Earthworks	We have been able to dig two swales on contour to hold the flow of water on the land and infiltrate it. We have also dug a pond on the low point of the orchard. These structures are an experiment to assess the water holding capacity of the soil and how these structures affect the water flow on the land.

Conclusions & next steps

1. This fund has helped us to get started on some very crucial works in the orchard by trying different things with respect to the floor management, soil fertility, planting, grafting etc. and this helps us to plan the way forward to realise the full potential of this orchard.

2. The biggest learning has been that we need to replace the varieties of Mangoes that are not desired with varieties that have high demand and can be processed. This is the main focus for the next years provided we have funds to invest in pruning and grafting.

3. The grafting has to go in parallel with better irrigation systems in the orchard. We have a system of microirrigation that works, we just need more funds now to implement this design.

4. Another major shift we have been able to do is change our birds from white to Hyline brown. These birds are better adapted to free range. To raise these birds on our own, we now have built a new coop and will be able to replace all our white birds by 2026.

Project accounts

Link to google sheet

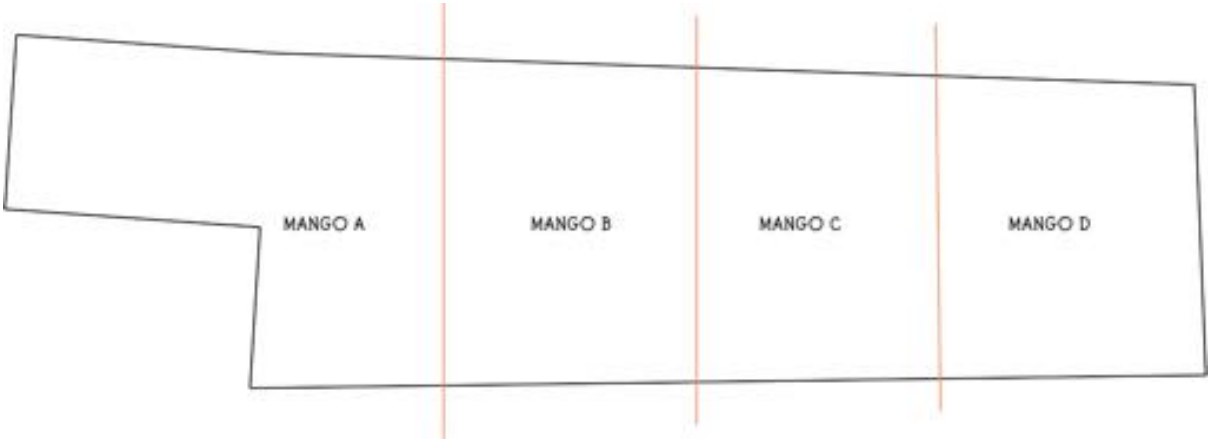
#	Date	Budget Heading and Items	Amount	Comments	Balance INR	Balance Euro 1€ = 80 INR
1	30/3/21	Grant from PCG	352477		352477	4406
2	11/1/22	Plantation	-20520	JCB to dig planting holes	331957	4149
3	21/1/22	Plantation	-12500	Compost	319457	3993
4	22/2/22	Plantation	-13315	External labour hired	306142	3827
5	28/2/22	Admin/Project manager	-17000	HTE for 2 months @ 8500	289142	3614
6	15/3/22	Irrigation	-21117	Plumbing materials for connecting irrigation system for newly planted trees	268025	3350
7	15/3/22	Irrigation	-7200	Plumbing labour/ 12 days @ rs. 600	260825	3260
8	15/3/22	Irrigation	-9700	1000 l tank	251125	3139
9	17/7/22	Orchard management	-5,575.50	Brush mgt. experiment (BRUSHCUTTING INVOICE NO. 2351)	245550	3069
10	6/8/22	Analysis	-6,903.00	Soil tests for comparsion of orchard soils	238647	2983
11	9/8/22	Orchard management	-21,682.50	Brush mgt. experiment	216964	2712
12	28/1/23	Irrigation	-4,720.00	Repair of irrigation pump relay	212244	2653
13	12/7/23	Planning	-8,900.00	Visit of expert	203344	2542
14	13/7/23	Irrigation	-14,768.00	In line laterals for coffee and turmeric irrigation (Netafim invoice dt. 9-5-23)	188576	2357
16	2/9/23	Rejuvenation	-6400	Expert visit for mango rejuvenation	182176	2277
17	2/9/23	Pruning	-9100	Two month support (4550) for team member for pruning work	173076	2163
18	2/9/23	Pruning	-1600	Labour charges for shredding	171476	2143
19	2/9/23	Rejuvenation	-800	Labour charges for irrigation channels for grafting trees	170676	2133
20	8/9/23	Plantation	-6600	New Mango plants to replace dead trees	164076	2051
21	8/9/23	Pruning and Shredding	-2000	Support for Aurovilian helping in Mango Orchard	162076	2026
22	19/9/23	Earthworks	-5298	Earthworks- remove dead mangoes	156778	1960
23	7/10/23	Earthworks	-3953	Earthworks- swales and ponds	152825	1910
24	19/9/23	Pruning	-1888	Cutting of big logs that were removed by the JCB	150937	1887
25	15/9/23	Irrigation	-7233	Irrigation material- pipes, valves	143704	1796
26	16/9/23	Rejuvenation	-10120	Planting material + transport	133584	1670
27	2/10/23	Pruning	-4550	Support for Aurovilian helping in Mango Orchard	129034	1613
28	2/10/23	Pruning	-3000	Support for Aurovilian helping in Mango Orchard	126034	1575
29	30/10/23	Orchard management	-2000	Labour charges for cleaning mullu etc.	124034	1550
30	1/11/23	Pruning	-4550	Support for Aurovilian helping in Mango Orchard	119484	1494

31	2/11/23	Rejuvenation	-8000	Expense for grafting, transport, boarding and lodging of skilled professionals	111484	1394
32	2/11/23	Plantation	-1500	Cost of plants	109984	1375
33	3/11/23	Orchard management	-1000	Labour charges for cleaning mullu etc.	108984	1362
34	7/11/23	Earthworks	-3448	JCB for digging swale	105536	1319
35	10/11/23	Earthworks	-3112	JCB for digging the first pond	102424	1280
36	10/11/23	Plantation	-2000	Labour charges for planting acacia	100424	1255
37	25/11/23	Plantation	-2100	Labour charges for planting acacia	98324	1229
38	11/12/23	Plantation	-1000	Labour charges for planting acacia	97324	1217
39	19/1/24	Poultry	-28850	Purchase of brown chickens	68474	856
40	17/2/24	Poultry	-2800	Tarpaulin for chicken protection	65674	821
41	19/2/24	Poultry	-6500	Transport of day old chicks	59174	740
42	2/3/24	Poultry	-59000	Towards construction of poultry coop for brown birds	174	2

Details

MAPPING & ZONING

The entire Mango Orchard is about 10 acres. One of the challenges in management is the size for planning. We have divided the orchard into four sections- A, B, C and D to look more closely at each section, focus on one part at a time and therefore be more effective in managing the orchard. This also helped us to plan the successive steps and prioritise the needs in each zone.



A schematic of the zoning in the Mango Orchard

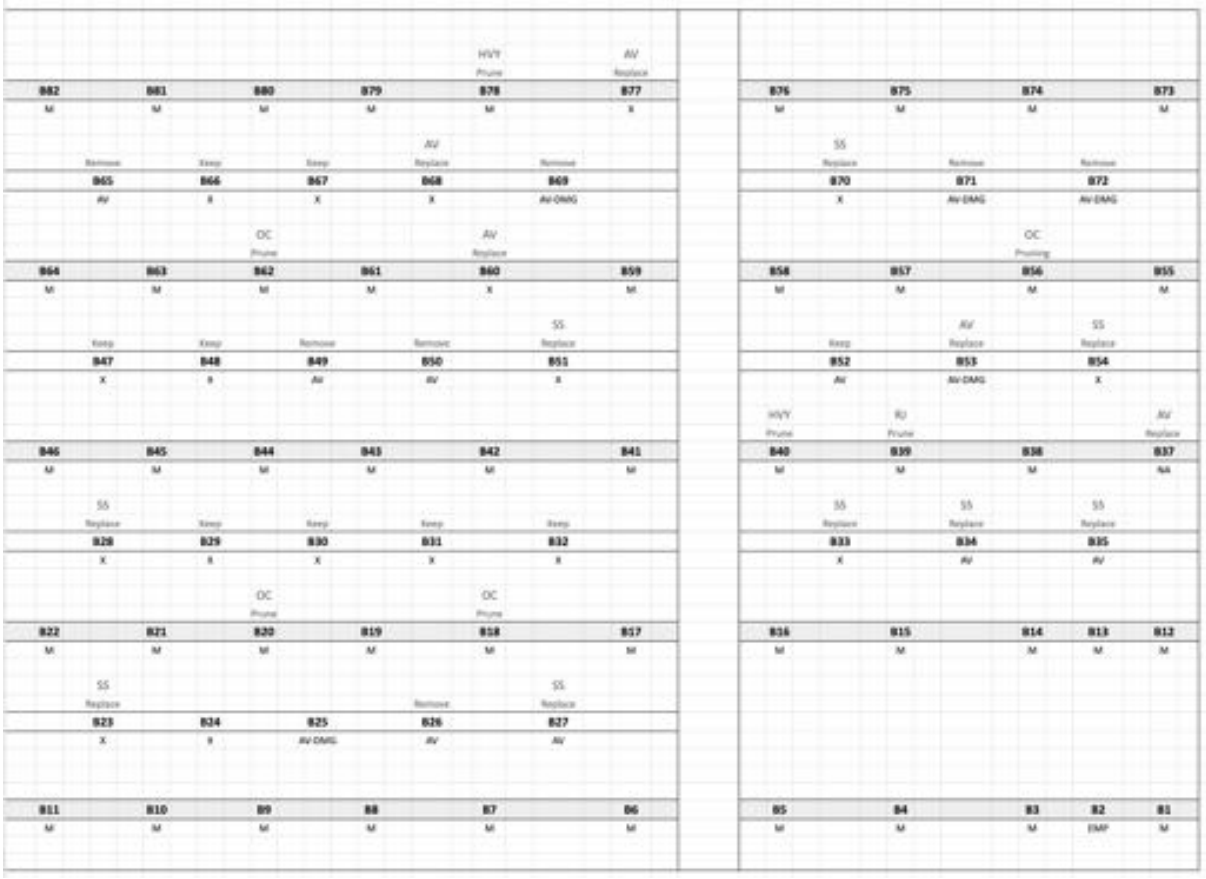
Zone	Approx area	Characteristic and proposed use
A	2.5 acres	No new planting done, can be used for cows for the next few years
B	2 acres	New planting done. Closest to the centre and therefore the first zone to focus on for next steps. This is where the chickens could come.
C	2.5 acres	New planting done, some open spaces where more trees can be planted, no special use imagined for now
D	3 acres	New planting done, some open spaces where more trees can be planted, no special use imagined for now

After some months of experience, we may decide to split zones C and D into 3 fairly equal zones (C, D & E). This will make all zones pretty much the same size of zone B which we feel is a good size to work with in a particular season..

NUMBERING THE TREES

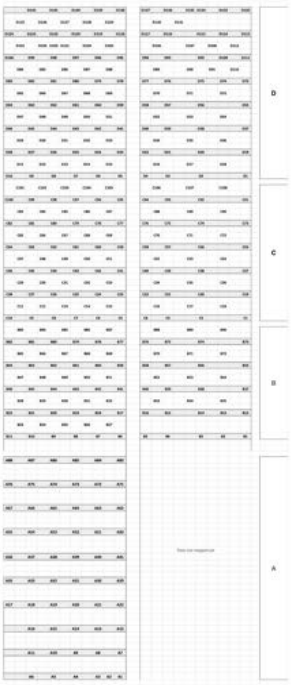
It took us several afternoons of going zone by zone, to go tree by tree and number them.
These were then compiled on a sheet and details of each tree corresponding to its number were noted down.
This helped us to make a map for each zone.

List of all the trees in the mango orchard can be found here.
Maps of each zone can be found on the same sheet. These are some snapshots of the same.



Map of Zone B

(Grey rows are old Mango trees, white rows are newly planted trees)



Map of Mango Orchard

(All trees have been numbered and mapped, except some trees in Zone A that are part of the existing chicken free range

SOIL TESTS

The first soil test to be carried out was a soil texture and biology test.
The method used was a simple jar test to separate the different mineral particles of the soil and observe the proportion of sand, to silt to clay and organic matter.

For the biology test, microscope analysis was done using Dr. Elain Ingham's (https://www.soilfoodweb.com/) soil microbiology test protocol.
The tests were done for different locations on the farm. The following table shows the data that was obtained from the analysis and gives the values as observed also in the compost prepared on the farm for comparative analysis.

Test 1: Microbiology analysis

Sample	**Mango Orchard**		**Coconut orchard**	**Block 5**	**Compost**
Depth of Sample	**0-10 cm**	**0-10 cm**	**0-10 cm**	**0-10 cm**	
Date of sample collection	23/08/21	01/11/21	01/11/21	01/09/21	25/10/21
Date of analysis	23/08/21	01/11/21	01/11/21	01/09/21	25/10/21
	(before ploughing)	(after ploughing)			
TEXTURE ANALYSIS					
Organic matter	5%	2%	2%	5.50%	94%
Sand	85%	86%	88%	78%	2%
Silt	2%	3%	4%	3.50%	2%
Clay	8%	9%	6%	13%	2%
MICROBIOLOGY ANALYSIS					
Bacteria					
Biomass (µg/g)	2201	3701	2886	6456	4158
(Standard deviation)	(188)	(184.43)	(182.43)	(760.21)	(105.83)
Diversity	Moderate	Moderate	Low	Moderate	High
Beneficial Fungi					
Biomass (µg/g)	388	356	475	95	7287
(Standard deviation)	(0.09)	(0.45)	(0.55)	(0.04)	(0.017)

Diversity	Low	Moderate	Low	Low	High
Beneficial Fungi Diameter					
(µm)	2.3	1	1	2	2.7
Notes	*Fungal diameter is an indication of health of fungal populations. By itself it does not signify much. It can be used to compare with the fungal biomass and see the growth of fungus within the overall population in a sample.*				
Protozoan Numbers /g					
Flagellate	0	203800	0	203800	203800
Amoebae	254750	1019000	4,07,600	1019000	1019000
Ciliates	0	0	0	0	
Total	254750	1222800	407600	1222800	1222800
Notes	*Protozoa are primarily bacterial feeders. High numbers generally correlate with high bacterial populations. Protozoa are responsible for nutrient cycling, feeding on bacteria and releasing available nutrients for plants. Lack of protozoa irrespective of bacteria and fungi means there is not enough active nutrient cycling in the soil.*				
Nematodes numbers /g					
Bacterial-Feeders	*None observed*	*None observed*	*None observed*	*None observed*	100000
Fungal-Feeders					0
Predatory					0
Root-Feeders					0
Notes	*Nematodes are higher predators and feed on both bacteria and fungi and contribute to overall nutrient cycling. No nematodes were observed in most samples. These samples should be reassessed in different seasons to confirm if nematodes are really present or not.*				
F:B Ratio	0.176	0.096	0.165	0.015	1.75
Notes	*Fungal- Bacterial ratio is an indication of the stage of the succession of the soil. Desirable ratios are (1) Vegetables and annual plants: 0.3 to 0.75 | (2) Grasslands/pastures/grains: 1 (3) Shrubs and perennial crops: 1 to 2 (4) Orchards: Above 2*				

A physical and chemical test was then done in August 2022 at the ADN Laboratories, Pondicherry. Again, the test was done for the Mango orchard along with 2 other locations on the farm for comparative analysis.

Test 2: Physical and chemical analysis

Parameter				**Notes**
Location	**Block 5**	**Coconut orchard**	**Mango Orchard**	
Date of sample collection	27/7/2022	27/7/2022	27/7/2022	
Date of testing	1/8/22	1/8/22	1/8/22	
Depth of sample collection	60-100 cm	60 -100 cm	60 - 100 cm	
Sand %	28.7	30.5	41	
Silt %	21.3	38.3	19	
Clay %	50	31.2	40	
Texture	Clay	Clay loam	Clay	
pH	6.04	5.86	4.78	
Electrical conductivity (microS/cm)	25.4	24.3	18.2	
Water content (Moisture) (%)	8.92	13.15	7.2	These plots have varying cycles of irrigation
Organic carbon	0.13	0.13	0.15	
Organic matter	0.23	0.22	0.26	
CEC (meq/100g)	10.3	9.53	7.77	
Available Potassium (meq/100g)	BDL	BDL	BDL	BDL= Below Detection limit (Detection limit= 0.5)
Available Phosphorus (mg/Kg)	33.2	27.1	27.4	

Observations:

1. The biological soil test (test 1) was done for the top 10 cm and the physical/chemical test (test 2) was done for 60-90 cm depth of soil. It is interesting to note the difference in soil composition at these strata. While the top soil is predominantly sandy, the sub soil is predominantly clayey.

2. According to test 1, the F:B ratio for Mango orchard soil decreased significantly after ploughing. This is due to the damage ploughing would have caused to the fungal networks in the topsoil. Fungi take a long time to repair and therefore to maintain a good F:B, ploughing or any external soil movement should be avoided. Also an increase in bacterial biomass can be seen after ploughing. This is due to the high availability of organic matter and dead organisms which immediately become food for bacteria and therefore promote their growth.

3. According to test 1, the bacterial biomass is higher in Block 5 while the fungal biomass is higher in Mango and Coconut orchards. This would be due to the higher density of planting in Block 5 which creates 'higher dynamic activity' in the topsoil. Fungi grow slowly and generally tend to 'preserve' energy. That is why fungi are abundant in old growth forests. This is also confirmed from the results of test 2. The organic matter is higher in Mango Orchard (and Coconut Orchard) as compared to Block 5. This is due to addition of biomass through falling leaves etc. which is not a case in Block 5 as it is still young.
   In general young systems will have a lower F:B and older established systems will have a higher F:B. The tests here confirm this.

4. The results for organic matter value and relative percentage are concurrent in both the tests.

5. In test 2, it is interesting to note that Block 5 soil has 50% clay and Mango Orchard has 40% clay. The organic matter values for both the soils are relatively the same (just a bit higher in the Mango Orchard). For this reason, the CEC seems to be higher in Block 5 (As CEC refers to the capacity of clay and humus-colloids in the soil to hold on to cations like Na, K, Ca, Mg, Al). Of course, this may not be the only reason and there is more to soil biology and chemistry than we can analyse.

6. Now that we have planted coffee on a section of zone B, we will not be bringing a tractor there.However, the rest of zone B might continue to be maintained with light disking. It would be interesting to compare the soil analyses of soil from the coffee area and away from it in zone B and see how management styles contribute to soil health.

7. Lack of potassium in the orchards will need to be addressed somehow considering the importance of potassium in the growth of trees and fruiting.

PLANTING NEW TREES

The mango trees have been planted in a grid of 15 m x 15 m. While in some places the trees have significantly to cover the entire space, there are areas where there is space for some other kinds of trees. Also the trees that are young have ample space around them for some other tree to come up. The motivation to keep trees smaller through pruning and have more space for other trees is the ease of harvesting. It is difficult to harvest mangoes from very big and high trees and this also requires special skill to not damage the tree or the fruit.
The experiment is to see how dense the plants can be planted and what can be planted in these spaces. New planting was done only in Zones B, C and D.

Spaces were identified in between the existing Mango trees

After several discussions within our team, we realised that we did not agree on a particular method of planting. *Planting methods vary from region to region and also depend on the plant being planted and the season.*

Planting method 1

To plant the new trees, a JCB was hired to dig holes in between the existing trees. The holes dug were 1 m in depth and 60 cm wide square. This was done in January 2022.
The 1 m deep holes were filled back with a mix of the top soil and aged cow dung, up to half of the hole. The plant was planted in the hole below the level of surrounding land (about 30-40 cm).
The intention here was to keep the plant at a lower level to allow better water percolation in the pit.

JCB dug holes 60 cm x 60 cm x 100 cm

Trees planted about 30-45 cm below the surface of the ground

A total of 150 holes were dug for the new plants and the following were planted during March 2022:

	# planted in March 2022	# survived by September 2022	Survival rate	Observations
All spice	2	1	50%	Mortality due to lack of water.
Avocado	66	28	42%	Most plants planted in full sun died. Plants in shade did well. Some plants were damaged by wild boars.
Bael fruit	11	3	27%	Mortality due to lack of water.
Black sapota	2	1	50%	Mortality due to lack of water.
Egg fruit	15	10	66%	Most of these did well. Some could have suffered due to lack of water and some were damaged by wild boars.
Jackfruit	25	16	64%	Most of these did well. Some could have suffered due to lack of water and some were damaged by wild boars.
Longan	3	1	33%	Mortality due to lack of water.
Soursop	36	26	72%	Most of these did well. Some could have suffered due to lack of water and some were damaged by wild boars.

Average survival rate: 53%

One of the reasons for low survival was lack of water. The trees were planted in March just before summer. The intention was to water the trees during summer and help them establish a good root system before monsoon. However, we quickly realised that it was not very practical to irrigate all the newly planted trees, especially as our irrigation system was not well established.

Also, irrigation of the entire mango orchard is very time consuming and we were often busy with other farm works and not able to dedicate time and labour for this work.

We have decided to plant before monsoon next year to avoid this.

Planting method 2

Some of us felt that we should plant on the level of the ground, especially keeping the level of the soil around the plant the same as it was while the plant was in bags.
The holes in this method are much smaller, are easy to make with simple hand tools and can be made with volunteers. The planting is also easier as it does not require a lot of soil to be moved. The effort is in covering the planted soil with compost and mulch which feed the roots gradually.

We will continue to observe the differences in how these trees perform and the pros and cons of these two ways of planting.


Plants planted at level of the soil in smaller holes
with compost and mulch covering the soil around the plant

Update
Planting method 2 has shown success and therefore is much more efficient as it requires much less preparation

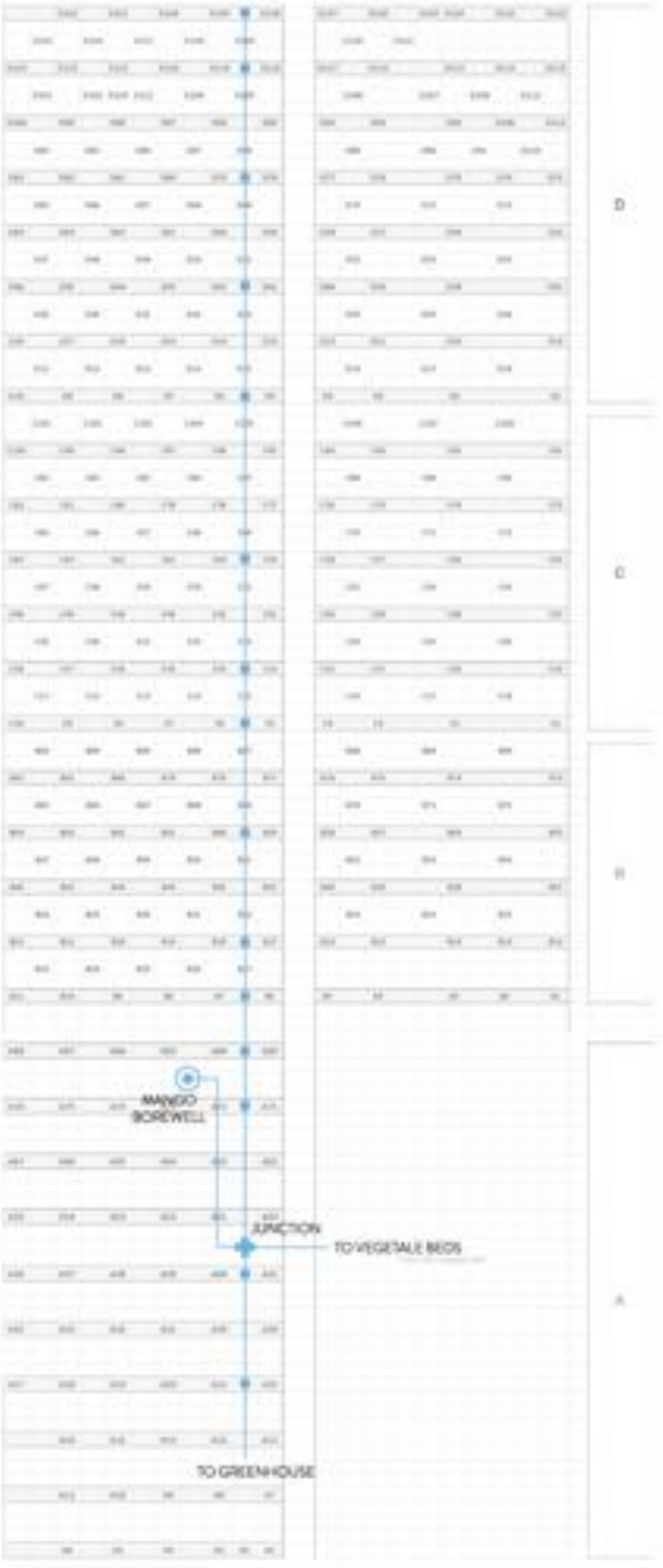
Before monsoon of 2023, we have planted more Mango trees in between the existing trees alongwith some Pomelos in Zone B..

IRRIGATION

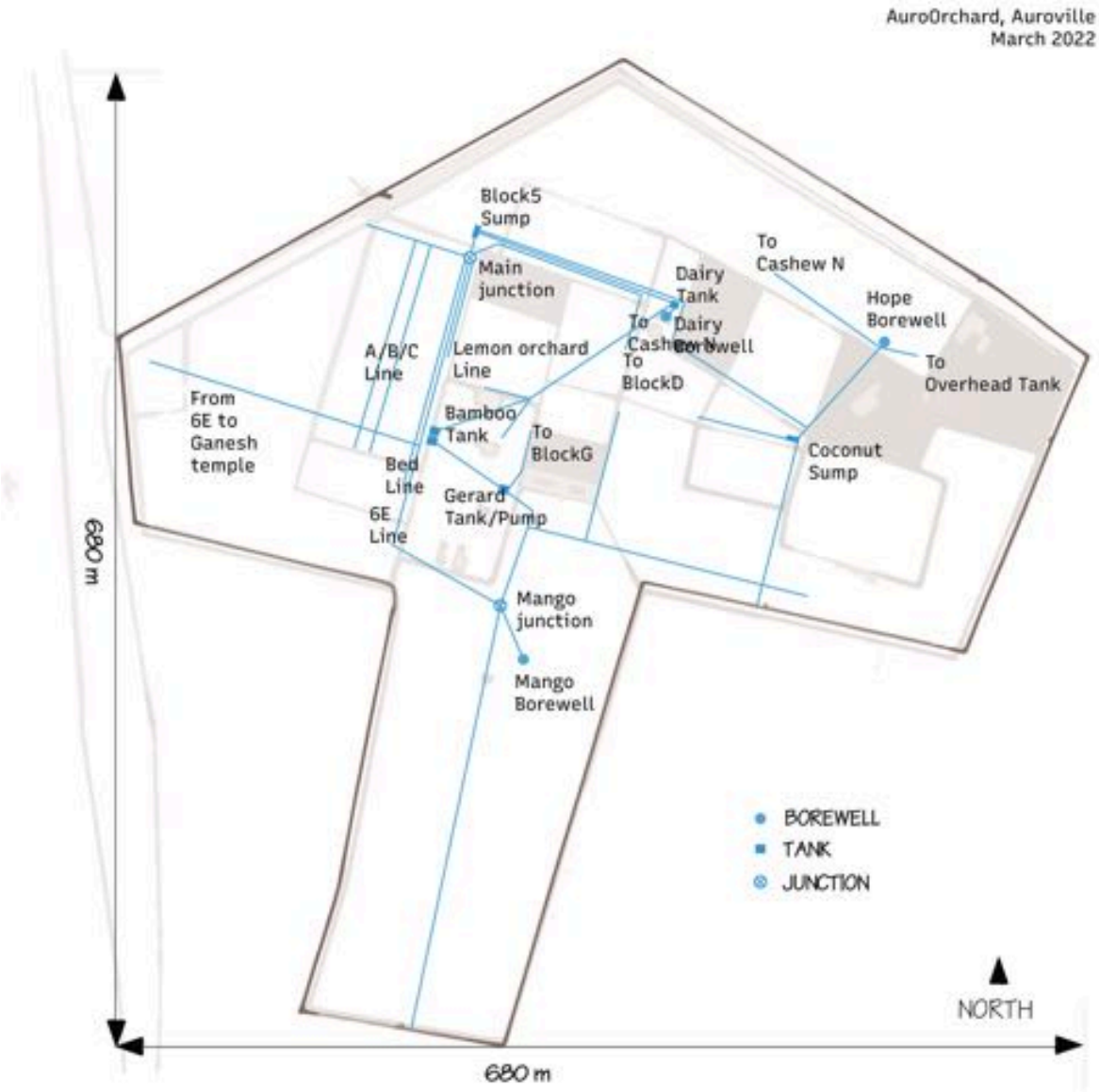
The Mango Orchard has had a very extensive and functional irrigation system in the past. Drip pipes were being used to irrigate the mango trees. There was even some vegetable cultivation in some open areas. The cleaning around the trees would be done manually and naturally, the area would turn wild without active weeding.
To be able to manage the brush in the orchard using machines, drip pipes were removed in 2014 so that a tractor could go in.
Since then, the irrigation for the trees is done through water channels from the 15 taps distributed along the length of the orchard.
This water used to come from either of the two borewells which have been there on the farm since the beginning.
In 2020, a new borewell was dug in the Mango Orchard for redundancy.
This borewell will be the primary source of irrigation in this area.
With the grant money, we were able to connect the new borewell to the existing irrigation systems.

New Mango Orchard Borewell

A system that connects the Mango Borewell to the existing irrigation system in the Mango Orchard and to the entire farm



Irrigation system across the Mango Orchard



AuroOrchard irrigation system
The Mango borewell is is now connected to the entire farm through the Mango Junction

The newly planted trees are currently irrigated by a hose connected to the taps. It is a time consuming process, all trees cannot be watered at the same time and there is wastage of water due to leakages etc.
We are imagining a micro irrigation system for the new trees either using drips or sprinklers.
We will try this out on a small area and explore how it works.
The concern is the difficulty of using machines to manage the orchard floor once micro irrigation is set up.

ORCHARD FLOOR MANAGEMENT

The physical and chemical properties of the orchard's soil need to be maintained in a good condition to ensure that root growth occurs without difficulty. However, weeds need to be controlled, people and machinery need to move around in the orchard, and irrigation needs to reach all of the trees. Typically, the main orchard floor management systems used in the world are mechanical cultivation, cover crops, mulching and keeping the soil bare with herbicides!

We have so far been cultivating with disc harrow or rotavator. This is quite effective with annual weeds and it helps break the crust that sometimes forms and allows incorporation of fertilisers and organic matter. Its shortcomings are that it disturbs the soil every time and most likely damages the root system. The wounded roots could also be an entrance to pathogens. The destruction of irrigation ditches or furrows is another problem. Presence of pipes and hoses also limits the use of cultivation, and the multiplication of weeds with underground structures (nutgrass) is also a challenge. In the past years, we have been ploughing the mango orchard about twice in the year.

While the soil got disturbed every time we ploughed the orchard, the fact that we were adding biomass in the soil, somehow compensated for the loss to the soil (at least in our minds). Overtime, we just got used to it.

This year with a new perspective on management of the Mango orchard, we felt we should explore other ways of cutting the grass. We hired the Auroville Tree Care team to do a full brushcutting for the 10 acres of the orchard. This seemed a bit strange at the beginning but it has worked out really well. The brush-cutting took place in the last week of July 2022. It took 66 hours in total to do the job. 2 men spent over 4 days carrying brush-cutting machines on their backs, the shaft fitted with a blade (instead of a wire).
We had a budget of Rs.20,000 (labour+tractor rent+diesel) for ploughing the area. We ended up spending a little over Rs. 27,000 (@Rs.350/hour +GST) for the brushcutting. The benefits of cutting the grass at the base, without disturbing their root system or the soil, of course, more than compensates for the cost difference.
We need to now observe how fast the grass grows back and how many times we would need to brush-cut to maintain the orchard. We are also exploring how this activity can be made more efficient. We are looking for some tractor implements that may help reduce manual labour in carrying heavy machines to this work.

In addition to brushcutting using the traditional brush cutters or specialised flail mowers, we also plan to experiment with shallow ploughing of the orchard using our disc harrow. We will try to avoid ploughing under the canopy of the trees where the weeds are not present, thereby avoiding any damage to the feeding roots of the trees.

Another solution is using a green manure or cover crop. However, we need a proper irrigation solution for this. Also, it would make sense to integrate cows or poultry with this so that the grown cover crop can serve as fodder/food for the animals. We will only attempt this once these details of these elements would work together are clearer.


Before brushcutting




After brushcutting

GRAZING

Zone A has been designated for cow grazing. Now new planting has been done here and the side branches of trees have been pruned so that the cows can pass under the trees easily.
At the moment, the cows are only grazing the wild grasses here and we do not have a plan for green manuring or fodder grasses in this zone.
We would like to assess the needs of the cows after this new arrangement and plan how best to address it during next monsoon.

We would also like to observe how this zone differs from the other zones where cows don't graze with respect to the floor management, the growth of weeds etc.

Cows grazing in zone A of the Mango Orchard

COFFEE

Coffee is a large evergreen shrub grown for its beans which are toasted and ground to obtain coffee powder. A lot of coffee is used in Auroville by people from across different cultures who have settled here.
Most of this coffee is sourced from the hills of Tamil Nadu, Kerala and Karnataka. Coffee likes warm and humid climates (varying from 15 to 28 deg. C) with an annual rainfall of 1200 to 1500 mm. Typically it is grown on higher altitudes where this temperature and moisture can be maintained throughout the year.
Traditionally, Auroville and this coastal region has not been cultivating coffee.

However, some **Arabica** (*Coffea arabica*) and **Robusta** (*Coffea robusta*) varieties of Coffee plants were brought to Auroville in the 1980s and planted in the Revelation forest which lies about 6 km northeast of Auroorchard.
For a long time they were left unnoticed and lately it caught the attention of the community and some beans were offered to Marc Tormo who to evaluate the quality of the coffee. Marc is a coffee lover and sources coffee from different parts of the world and processes quite a lot of it for his cafe in Auroville. According to Marc, it is really good coffee and has a unique taste. This could be an opportunity to develop an Aurovilian variety of coffee, considering the demand of coffee in Auroville. It will not only help in localising the coffee production and distribution, but the coffee plant itself is a very interesting addition to the biodiversity of the forests and farms as it can grow in partial shade and grows like a bush which allows interesting combination with trees and in multi-layered farming models.

We met with Marc and Dave from Marc's coffee and Jeanluc from Revelation to explore this idea further. We decided to pilot 100 coffee plants in AuroOrchard as a trial and then evaluate how and where the plants grow best.

The Mango Orchard seemed, immediately, a great option to try coffee cultivation due to the desired microclimate and the space available. We decided to plant around 50 plants in the Mango Orchard and the rest in 2 more locations on the farm to see how the plants respond to the soil and conditions of AuroOrchard. Each orchard has a unique characteristic of availability of sun, soil quality, irrigation and moisture available and ease of access and management. Based on our observations, we can plan better for a larger production.
Marc would also like coffee to be seen as a valuable crop like cashew and perhaps this could be offered as an alternative/ combination to cashew and other monocultures.

Coffee has hundreds of varieties and each region in the world has their own special coffee .
with particular flavour and properties. However, Arabica and Robusta are the two most popular varieties.
Some known varieties of coffee:
Arabica *(Coffea arabica)*
Robusta (*Coffea robusta / Coffea canephora)*
Liberica (*Coffea liberica)*
Highland Coffee from Sierra Leone (*Coffea stenophylla*)

The coffee plants to experiment with in the Mango Orchard are coming from Kerala. These 4 varieties are being planted:

1. CxR (*Coffea robusta crossed with Coffea congensis*)
2. Robusta dwarf (A selection of *Coffea robusta*)
3. Robusta

From left to right: RxC, Robusta dwarf, Robusta

We are also trying to germinate seeds from the existing coffee plants in the Revelation forest as these seeds would be more appropriate after 30 years of being growing here. However, germination of these seeds has not been very good.
The idea is to continue trying to get these plants to develop while trying to cultivate some other desired varieties brought from outside.

Ideal conditions for coffee cultivation

1. Well draining soil
2. Rainfall/moisture requirement 1350 mm (will need irrigation in our context as moisture needs to be throughout the year)
3. 50-75% shade
4. Spacing of 3 m x 3 m for Robusta and Robusta x Congensis and 2 m x 2 m for Robusta dwarf
5. Pruning regularly to maintain height and shape

Location

Three areas were chosen for coffee planting at AuroOrchard:

1. **East section of Mango Orchard Zone B**
   Because the mango trees here are relatively young and can be pruned to allow space for coffee plants.

2. **Block 5**
   Because there are spaces in between trees that could be very interesting for coffee. Also this area is not being tilled and therefore the soil quality here is much better than the mango orchard.

3. **Vegetable beds area**
   There are two beds next to a hedge which receive a lot of shade and therefore are not suitable for vegetable cultivation. Coffee here could be interesting.

Coffee planted in Mango Zone B

Coffee planted in Block 5

Coffee planted in vegetable bed area

Planting method

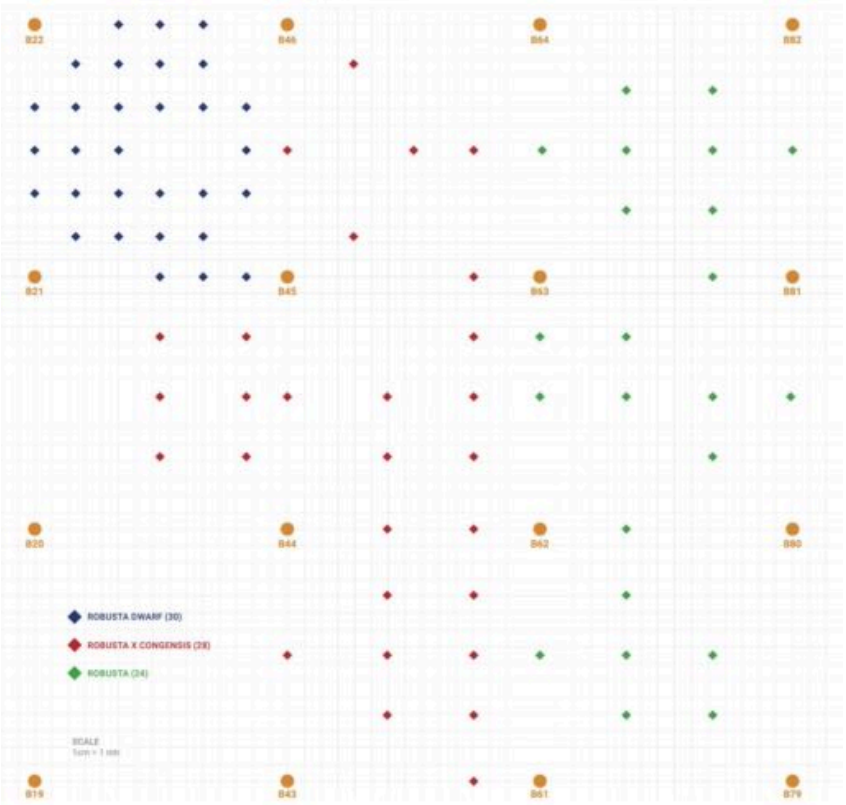
Saplings were planted in the last week of October 2022. We were fortunate to have good rains and therefore the soil was moist and soft. Holes were dug just a bit bigger than the nursery bags in which the saplings were. Using the crowbar a deep hole was made below this hole to allow space for water and tap root to go deep. In this hole, only a handful of compost was put. Saplings were carefully planted into the hole after cutting any roots that had grown out of the nursery bag.

Care was taken to make sure that the final level of soil around the plant was the same as when it was in the nursery bag. This was done to protect the root crown.

After planting a good amount of compost and mulch were put around the plant.

A 30 -45 deem hole with a deeper hole at the bottom. Compost was put in the hole prior to planting.

Planting, composting & mulching



A schematic of coffee planted in between the existing mango trees

Irrigation

Micro irrigation has been done using drip pipes connected to the existing irrigation system in the Mango Orchard.

Management

We are not sure if coffee plants will require pruning. We will decide this after 1-2 years depending on the space each plant requires and the desired height and canopy.

Harvesting & Processing

We can expect the first harvest to be in 2025. The process of harvesting and processing has been discussed but needs further planning.

Intercrops

We have interplanted coffee with turmeric. There was damage due to wild boars so this needs more attention this year.

Resources

History of Coffee | Coffee processing (video from Uganda) | Ways of processing coffee
Coffee intercropping | Banana coffee interplanting | Ideas for intercrops for Mango orchards

PRUNING

Pruning in itself is a very controversial subject. Whether to prune or not and how much to prune is something you can find diverse opinions on. We considered pruning our mango trees for the following reasons:

1. **To remove the dead branches** *(Sanitary and management pruning)*
   It is natural that some branches in the big trees die or get damaged. It is part of the natural cycle of the orchard and its regenerations. However, such branches can fall and cause more damage to either the same tree or its peers. It can also be dangerous for people working in the orchard.

2. **To open the center of the trees** *(Structural regeneration pruning)*
   The center of the mango tree that grows vertically is the part that stores the food for the tree. It is what we call the vegetative part of the tree. So while more and more nutrition of the tree goes into growing this centre, the center also prevents sun from reaching the side branches which actually produce fruits. By opening the center, the tree gets stimulated to produce more fruits on the side branches and receive enough sun for better fruiting and ripening. An open center also helps with ventilation and therefore protects the tree from diseases.

3. **To maintain the size of the trees** *(Formation/ Production pruning)*
   With less and less people working on the farms, we need solutions for efficiency in tree management and harvesting. Trees that become too big are difficult to harvest from. By shaping and maintaining the size of the tree, harvests can be easier and bigger (although the lifespan of the tree may reduce) as the tree will put more energy in fruiting than vegetative growth.

4. **To graft desired varieties onto establish trees** (*Rejuvenation*)
   There are many varieties in our orchard but most of these varieties are not marketable due to other varieties being preferred for their flavour and processing potential.
   For this reason, we have decided to expand the no. of the desired varieties by grafting them onto the existing trees which have already established a deep root system. This means pruning down the existing trees heavily down to 1 m height and then grafting on the new shoots the variety that we desire. Such a tree would start yielding again within 3 years as opposed to a new sapling that would take about 5 years.

To start with, we decided to focus on a few trees for each of these prunings.
Some of the trees in the orchard are over 80 years old and we have been careful in selecting the trees for pruning and deciding how to prune to avoid any damage.

Image on the left shows a tree where lower branches were pruned to keep a clearance from the ground and central pruning was done to open the crown of the tree to sun and light. The image on the right shows severe pruning done on a tree to rejuvenate it. Most of the tree was drying up.

Season for pruning

Typically the best season for pruning is when the tree is hibernating as this prevents the tree from shock. Winter season is usually preferred as activity for most trees reduces during this season. However, in our region (south east coast of India), winter is also the monsoon season. Cuts made during monsoon are prone to infection as open wounds become places where pathogens can enter. The constant wetness also prevents the wound from drying and the tree to heal.

Therefore, we have a short window between the last Mango harvest and the onset of the monsoon, that is, **September to October** for pruning work.

Another perspective on this is that it may be better to prune after the monsoon when the sap in the tree is rising as the tree prepares for flowering. Pruning at this time could help in stimulating the tree. This would be right after the monsoon finishes and before the flowering starts, that is, **January to February**. This still needs to be experimented with.

We are planning to prune in both these seasons and observe the differences.

Resources

Cultural practices for Mango trees
Canopy management for Mango trees: How to prune older mango trees
Canopy management for Mango trees: How to train young trees
Cutting back/Rejuvenation
Conditional cutting (Hindi)
Mango Orchard pruning perspective (Tamil)

Mango Cultivation Guide from Tamil Nadu Agriculture University (TNAU)

About one metre from the base on the main trunk should be kept free from branching and the main stem can be allowed thereafter spaced at 20-25 cm apart in such a way that they grow in different directions. Branches which cross over/rub each other may be removed at pencil thickness.

Information from TNAU Agriculture Advisory System

Rootstock sprouts and low lying branches have to be removed. Remove overlapping, intercrossing, diseased, dried and weak branches in old trees to get good sunlight and aeration. For the internal branches, pruning may be done during August – September, once in three years. Flowering should not be allowed for up to three years. Among crowded terminal shoots, weak shoots are trimmed to retain two healthy shoots during August-September annually.

Organic Cultivation of Mango in Tamil Nadu

Pruning mango trees is important for tree size control and to improve the fruit colour. Essentially, tree pruning and canopy management is the same for organic or conventional production. Pruning is done to open up the structure to allow good airflow and adequate internal light. It also minimises disease risk and assists in good fruit colouration. Internal pruning to remove dead wood can be very important to help reduce the incidence of disease like stem end rot. Rootstock sprouts and low-lying branches have to be removed. Overlapping, intercrossing, diseased, dried, weak branches are removed to get good sunlight and aeration. For internal branches, pruning may be done during August- September, once in three years. Flowering should not be allowed for up to three years. Among the crowded terminal shoots, weak shoots are trimmed to retain two healthy shoots during August- September annually.

GRAFTING

We pruned seven trees (wild and Totapuri variety which is not used much) and grafted Banganpalli and Imampasand varieties onto them.

Making graft cuttings from the desired varieties. We chose Banganpalli and Imampasand varieties for this. Both are in high demand in Auroville and have a big processing potential.

Healthy young shoots from the tree are selected and then spliced to insert the graft. The site of grafting is then tightly wrapped with a plastic to protect the joint.

The grafts are then covered with a plastic to maintain moisture. In all, we grafted 7 trees.

Graft after six months. All shoots are healthy.

Grafted trees with the grafted shoots (and wild shoots that now need to be pruned)

EARTHWORKS

2 swales made on contour in the orchard as an experiment. We want to see how they work in this monsoon.

A big pond was made on the lowest part of the orchard. We can already see some clay at the button of the pond. We will have to see how much water fills this monsoon. Depending on the results we can plan to either expanding this pond or create more ponds to hold or infiltrate water.

POULTRY

AuroOrchard started its first poultry in around 30 years ago. These were BV 300 birds bought as one-day old chicks and raised on the farm. Once in AuroOrchard, they were raised in cages, a methodology that is very common in large scale poultry rearing both for eggs and meat.
At that point, there was only one coop and the chickens remained in cages throughout their life until their egg production would go down and then the chickens would be sold for meat to the workers and a flock would be bought. Considering the ethical implications of this method, around 10 years ago, this system was changed to “free-range” poultry. In this system, the chickens have the opportunity to run around freely for at least 6 hours in a day.
But we have still continued to use the same BV 300 birds and they are not adapted to free range conditions. To change, we have now moved to the Hyline brown variety. The fund helped us to create a new coop to start these birds and slowly replace our flocks. It will take us 3 years to completely move to brown birds.

The experiment with only 100 brown birds. They are much more active outside and disease resistant. In terms of egg production, they are comparable to the white birds.

New coop for 450 brown birds with their own free range. This is a starter coop. 1 day old chicks will be bought and raised in this coop and will replace the white birds after 6 months when they start laying eggs.

3 month old birds in the new coop

For questions and suggestions, please write to us at
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