Semilla Nueva Standard Report
July – December 2020

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EXECUTIVE SUMMARY

Three years ago, Semilla Nueva began to sell the world's first commercial high zinc, high iron, and high protein quality maize seed directly to smallholder farmers. Our work was born out of deep frustration. No matter how hard we tried, we could not convince Guatemala's poorest rural communities to grow and eat enough nutritious foods to make a dent in malnutrition. They remained almost entirely dependent on nutritionally inadequate maize eaten with every meal. We pivoted and channeled all our resources into a new idea: If we could make more nutritious maize seeds financially advantageous to rural farmers — would they start using them at scale? Could we get enough farmers to grow enough nutritious maize to decrease the nutritional deficiencies of an entire country?

After three years, we find ourselves with the experience to say how well this approach works, the potential it has, and what we need to do to scale it. Here are the most important strategic takeaways:

The big picture idea makes sense: We have seen now that when biofortified maize seeds are made economically advantageous to smallholder farmers, they will adopt at scale. Enough adoption will significantly decrease the deficiencies of zinc, iron, and quality protein for entire populations. Given that malnutrition is the world's number one cause of childhood death and given that most malnourished children in the coming decades will live in countries that depend on maize as a staple, this strategy deserves investment and prioritization.

Making biofortified seeds economically advantageous to enough farmers to reduce national nutritional deficiencies will require better seeds and some level of public policy. Both are feasible but will take work: To get biofortified seeds used by hundreds of thousands of families and biofortified grain eaten by millions of the most malnourished people will require some combination of 1) developing higher yielding biofortified seeds, potentially with better grain appearance, and 2) implementing some requirement or incentive for local seed companies to sell the seeds at scale. Given Guatemala's political realities and what appears feasible in terms of seed development in the next 3-5 years, we currently believe the best route is to simultaneously develop seeds with ~20% higher yields, and for a third party, preferably the Guatemalan government to provide seed companies with a small incentive to sell those seeds at reduced prices to farmers. We estimate the Guatemalan government would only need to spend $2-4 million dollars a year on incentives to seed companies to cut the most important nutritional deficiencies in Guatemala by 20-50% and improve the incomes of 100,000-200,000 families. This would be a disruptive and cost-effective way to improve rural incomes and nutrition for governments in Mesoamerica and Sub-saharan Africa. To make this work, Semilla Nueva must:

1) Improve the biofortified seeds that are available,
2) Grow sales of biofortified seeds to farmers to show they are commercially viable,
3) Pilot an incentive program with other seed companies, and
4) Build a coalition to design and implement this policy with the Guatemalan government.

This report provides extensive detail on Semilla Nueva's progress advancing towards each of these goals, as well as an improved understanding of the challenges we will need to overcome.

Impact Evaluation: Based on growth in Semilla Nueva's sales, our collaboration with farming associations, and our COVID-19 response program, 9,936 families planted our biofortified seeds in

2020—nearly double the 5,400 families in 2019. These families produced over 25,000 mt of more nutritious maize, enough to fill 700 shipping containers and feed nearly 300,000 people for a full year.

We successfully launched a new monitoring and evaluation system to enable representative economic, food security and marketing studies with the farmers who used our seed. The nutritional levels for biofortified grain have improved and farmers are producing, storing, and eating more biofortified maize than in previous years. Hurricanes complicated our economic surveys and prevented many families from participating, but initial data shows that seed performance caused by abnormal plants and low germination rates resulted in a slight decrease in yields and profit vs. competitors seeds. For farmers who normally did not purchase hybrid seeds, their incomes increased between 92-132% on land planted with F3.

Sales, Production, and Marketing: Even with the COVID-19 pandemic preventing in-person events that are the core of our seed promotion strategy, Semilla Nueva expanded sales of our biofortified seed, F3, by 37% and reached 85% of our original sales goals. Sales were on track until Hurricanes Eta and Iota hit; those disasters combined with a crash in grain prices due to government COVID-19 programs caused sales to decrease in the second half of 2020. Part of the F3 sold in 2020 had problems with low germination and abnormal plants that were due to challenges in seed production. These problems are rooted in F3's genetics and were largely fixed with more intensive seed production systems. However, significantly expanding sales of F3 will be difficult due to a combination of low yields and penalties many farmers face due to F3's slightly darker and smaller grain. Our next seed, F5, solves for some of F3's and will allow for additional growth. Developing improved biofortified seeds remains Semilla Nueva's biggest priority to continue scaling in the medium term.

Collaborations and Public Policy: In May of 2020 we launched a COVID-19 relief program which provided non-commercial quality seed to 1,835 subsistence farmers without the resources to buy it. Farmers increased their yields and incomes, proving that simply providing improved seeds without extensive training or other inputs is a viable program. An additional 3,400 families received seed in October 2020, but plantings were lost due to Hurricanes Eta and Iota. Semilla Nueva also convinced Guatemala's largest national seed company to pilot our incentive program. They planted F3 and will begin selling it under their brand at a reduced price to farmers in April 2021. Upon evidence of seed sold at reduced prices, Semilla Nueva will provide them an agreed-upon subsidy.

Semilla Nueva got over a dozen articles and interviews published promoting the use of biofortified seed by the Guatemalan government. We continued conversations with government officials about expanded biofortified seed use. Encouragingly, the Guatemalan Ministry of Agriculture announced two new programs which will use biofortified seed—one for an emergency strategic reserve with 5,000,000 lbs. a year of biofortified grain and another to provide seed to farmers directly.

Research and Development: Our next seed, Fortaleza F5, has significantly better yields than our current seed. It will be in over 100 farmers' hands in 2021. Pending positive results, we will launch it commercially in 2022. We hired a PhD breeder, expanded the field team, purchased all the equipment to build our own nutrition lab, and built an advisory board staffed with some of the world's leading scientists from the private sector. We have multiple strategies advancing simultaneously to develop seeds with better yields, grain size and color and over 2021, we will discover which of these approaches have potential. We are currently on track to have seeds for initial testing by 2023.

IMPACT EVALUATION

Summary:

- Semilla Nueva successfully reached 9,936 families during 2020, nearly doubling the 5,439 families reached in 2019. This does not include the over 3,000 families who received seed but lost their maize production due to Hurricanes Eta and Iota.
- Semilla Nueva's new methodology for representative sampling of farmers who purchased seed has been a major success.
- The average family who purchases F3 seed replaces 67% of their annual maize consumption with biofortified maize—an increase from the 51% identified in 2019.
- F3 grain had improved nutritional levels in our most recent lab testing, potentially due to improved quality control practices in seed production.
- A new nutritional analysis study will launch with Central America's leading nutrition think tank, INCAP. The study will evaluate the nutritional gaps present for pregnant women, lactating women, and children under two years in families who purchased or received Fortaleza F3, and the level those nutritional deficiencies decreased due to consuming F3.
- An insufficient number of surveys on the economic results of Fortaleza F3 were completed in 2020, because COVID-19 and Hurricanes Eta and Iota prevented field technician visits and caused early or late harvests. Economic results were below expectations, with farmers in the mid and low segments showing slightly decreased income for F3 vs. competitor seeds.

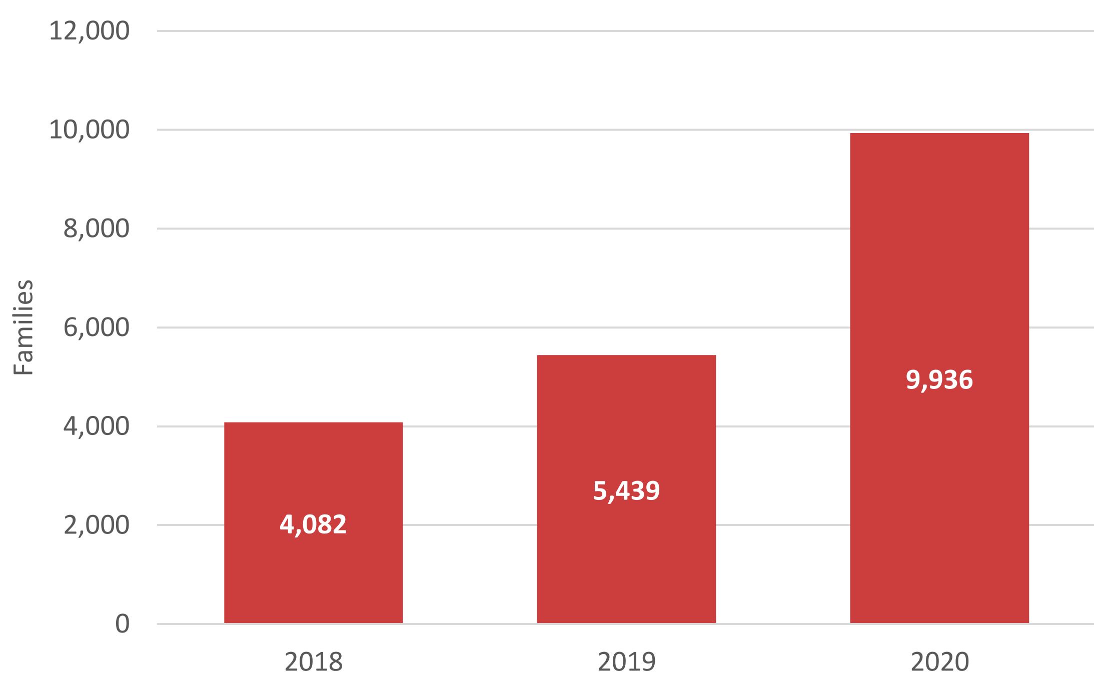


Figure 1: Families planting biofortified seed (2018 - 2020).

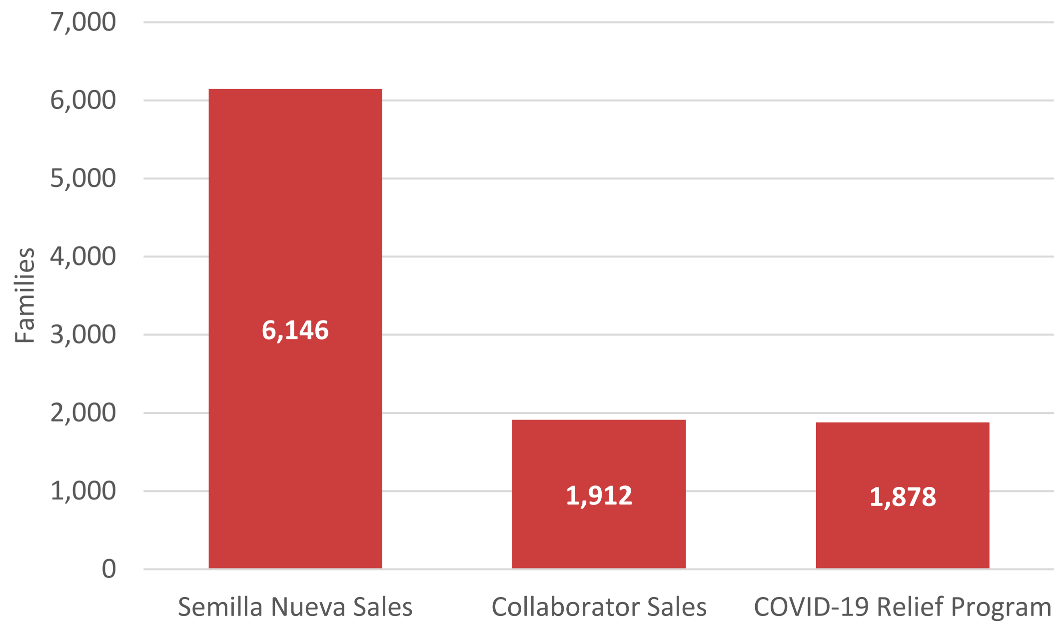


Figure 2: Breakdown of families planting biofortified seed in 2020 by source of seed.

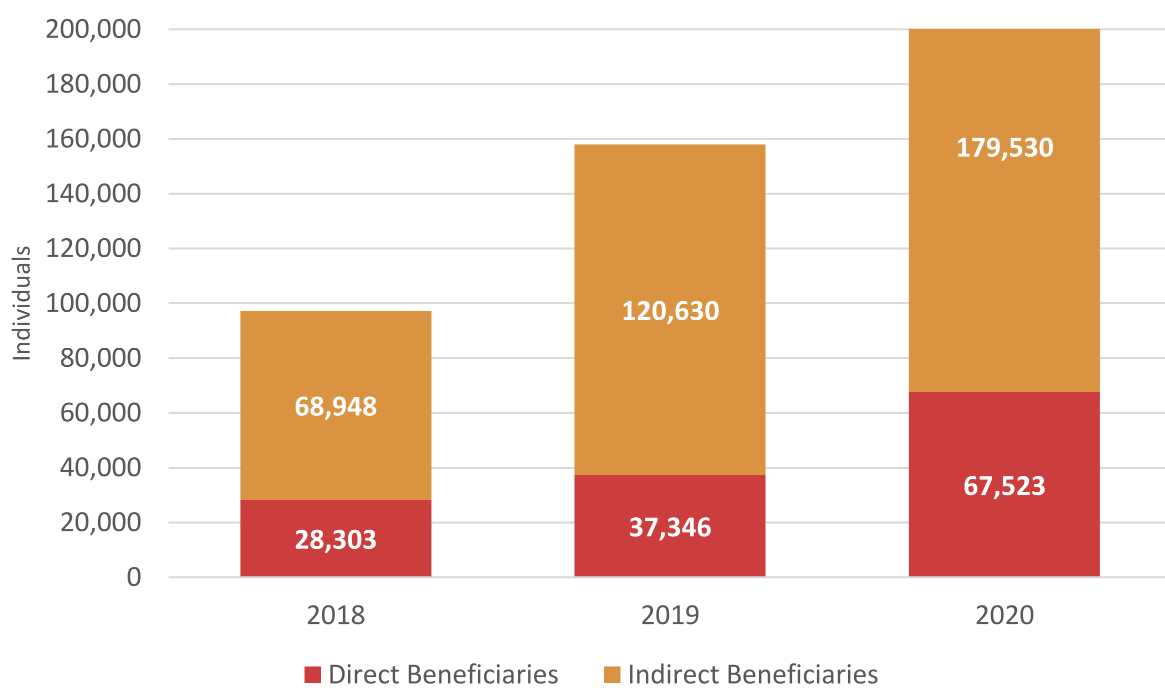


Figure 3: Number of direct beneficiaries (farming family members) vs. indirect beneficiaries (minimum consumers with improved nutrition).

Our new strategy for representative impact surveys was a success, and will be expanded in 2021: Over the past two and a half years, Semilla Nueva's biggest limitation in impact evaluation has been that we lacked a representative list of farmers to study. The farmers we surveyed were either known personally by our field technicians or had participated in promotional events, creating a biased sample. Semilla Nueva could only survey these farmers because the agrodealers which sell our seed are unwilling to write down customer information or share it with any companies.

Semilla Nueva launched our promoter program in April 2020. Temporary local workers were contracted to promote F3 in numerous participating agrodealers where our seed is sold throughout Guatemala. These ten promoters not only promoted our seed but also recorded contact information for all farmers who purchased seed at each location. In two months, they captured information from 631 farmers at 13 agrodealers where 19% of seed was sold. Over the course of September-December, these lists of farmers were used for every major marketing research and impact evaluation program. Response rates varied between 20-50% depending on the geographic location and month of the call. These new lists allow us to have a representative sample to examine the impacts of our seed on food security, nutrition, income, as well as learn more about farmers to more effectively market our seed. The program will be expanded in 2021.

Nutritional analysis of grain was completed. Zinc and iron levels remained at steady. Amino acids increased to close to originally expected levels:
Samples of both biofortified maize produced by farmers and conventional maize produced in their same field were sent to the nutritional laboratory at CIMMYT for analysis for a third year. As shown below, increased levels of iron and zinc over conventional maize have remained stable, with no significant differences across years, soil types or economic investments by farmers. This stability answers a very important doubt of critics within Guatemala regarding biofortified maize, namely: *Will biofortified maize still be more nutritious when produced in poorer soils and by poorer farmers*? Semilla Nueva is exploring publishing a paper with CIMMYT to provide our data in response to this doubt.

Table 1: Zinc and iron levels, Fortaleza F3 vs. conventional maize in farmers' fields, 2017-2019.

		Fe (mg kg^{-1})		Zn (mg kg^{-1})	
Year	**Locations**	**F3**	**Check**	**F3**	**Check**
2017	**7**	18.13	15.43	31.13	23.91
2018	**34**	17.45	14.82	33.31	24.25
2019	**16**	17.39	14.17	32.42	22.43
Average		17.51	14.71	32.79	23.70
Diff.		**19%**		**38%**	

As mentioned in our *January-June 2019 Standard Report*, levels for amino acids were lower than expected in Fortaleza F3 harvested by farmers in 2018 and analyzed in 2019. Semilla Nueva invested significant resources to clean our parental seed and improved quality control in our seed production processes. For maize analyzed in 2020, the amino acid lysine was at the full level expected.

Tryptophan levels also increased, and while not reaching the full goal were still in the range for protein quality biofortified maize as illustrated below. Variations between the two years could be due to improved quality control systems and/or other reasons. The production team will maintain the new quality control systems while we continue to take data in the following year.

Table 2: Amino acid levels, Fortaleza F3 vs. conventional maize in farmers' fields, 2018-2020.

Maize Type	Lysine (% of protein)	Tryptophan (% of protein)
Fortaleza F3 results 2018-19	3.37	0.50
Fortaleza F3 results 2019-20	3.96	0.57
QPM average (reference)	4	0.80
Opaque 2 average	2.7-4.5	0.5-1.1
Conventional maize average	2	0.40

Ex-Ante model was not expanded in 2020:
Semilla Nueva's M&E coordinator left in late 2019 to lead One Acre Fund's impact evaluation in Tanzania. Semilla Nueva hired a consultant who had previously assisted in ex-ante modeling for Harvest Plus to continue developing components for iron, protein quality, and use of seed by subsistence farmers. The consultant was unable to produce a significant addition to our 2019 work, and we are pursuing a new coordinator for the program for 2021.

The average farmer who plants F3 replaces 67% of their family's maize consumption with biofortified maize:
One important doubt on the impact of biofortified maize is: *Even if a farmer plants biofortified seeds like F3, how much of their family's total maize will become biofortified?* This is a difficult question given that 1) most farmers plant several seeds; 2) many will store some maize from each, and worse, 3) most farmers do not save enough maize from their harvest to get them through the whole year. Taking this into account, Semilla Nueva surveyed a representative sample of farmers who purchased seed throughout the country as well as who received seed for free in our COVID-19 relief program. The results were an improvement over surveys from 2018-9: Farmers save far more F3 maize than other kinds of maize, and on average save reserves to get them through most of the year. Given these two factors, if a farmer plants F3 during the main planting season, they will improve the nutrition of their entire family, every day for 8 months on average—replacing 67% of their family's annual maize consumption with more nutritious, biofortified grain. This is a significant improvement over the 6 months of consumption Semilla Nueva achieved in 2018-9 and may be due to farmers more heavily valuing F3 for home consumption due to the improved taste and texture of its tortillas.

Insufficient economic surveys were completed due to complications from Hurricanes Eta and Iota. Data collected shows farmers in mid and low-segment who grew F3 had decreased incomes, partially due to the low germination rates and abnormal plants mentioned in the Sales section. Farmers who normally do not use hybrid seed saw significant net income increases:

Table 3. Economic impact by segment and year 2019-2020 given average land planted.

Segment	2019 F3 vs Competitor Increased income ($)	2020 F3 vs Competitor Irrigation Season Increased Income ($)	2020 F3 vs Competitor Rainy Season Increased Income ($)
Mid-segment farmers	46	-2	-75
Low-segment farmers	37	48	-70
Non-hybrid farmers (purchased seed)		43	229
Non-hybrid farmer (received seed for free)			39

Semilla Nueva only harvested 25-side by-side parcels for economic evaluation in the fall harvest season out of a goal of 67. Whole regions were inaccessible due to Hurricanes Eta and Iota and their aftermath. Farmers were forced to harvest earlier than expected, mixed harvests, or transported grain to other locations. Nevertheless, the 25 mid- and low-segment farmers who did participate in side-by-side harvests and economic analysis showed a disappointing trend. Contrary to the previous year and the 2020 irrigated season, farmers on average showed slightly lower yields in their F3 parcels than in parcels of other seeds. On average, low-segment farmers had 4% lower yields with F3, while mid-segment farmers showed 8% lower yields on average. Parcels with the biggest differences in yields were largely due to the abnormal plants and lower germination rates mentioned in the Sales and Production sections, problems which we have largely been able to fix.

Two farmer segments did much better. Most of Guatemala's farmers do not purchase seed, both for economic and cultural reasons. Semilla Nueva targeted these farmers directly in sales campaigns and provided seed for free as part of our COVID-19 relief efforts. In these farmer segments, there was a significant increase in both yield and net-income. For subsistence farmers who purchased Fortaleza F3 increased yields by 68% and increased net incomes by 92%. For farmers who were given free, non-commercial seed (see the Collaborations and Public Policy section), farmers increased yields by 26% and incomes by 132%.

While economic impact is a secondary goal for Semilla Nueva (nutritional well-being is primary), economic impact is the medium through which Semilla Nueva will grow sales and adoption of biofortified seeds. The disappointing economic impacts in the low- and mid-segment show the importance of fine-tuning our seed production and the importance of launching new seeds with much higher yields, like Fortaleza F5.

SALES

Summary:

- Despite COVID-19 restrictions, uncommonly low prices, and hurricanes, sales of biofortified seed increased 37% in Semilla Nueva's third year. Semilla Nueva sold 2,981 bags of F3, 85% of our 2020 goal. Sales were on track to meet our goals in June, but low grain prices due to large governmental importations, and hurricanes Eta and Iota contributed to significantly decreased sales in the second half of the year.
- As COVID-19 restrictions began to loosen, the sales team continued with farmer visits and calls, launched promotion events at agrodealers, continued digital marketing, and began farmer trainings with social distancing and low numbers of attendees.
- F3 had several on-farm performance issues that contributed to sales headwinds. Some of the issues, including abnormal plants and low germination rates, can be improved with more stringent seed production strategies, while other issues like deformed ears and lower yields in the high temperature tropics are purely based on F3's genetics. Semilla Nueva may be able to grow sales for a fourth year, but improved seeds will be necessary for long-term growth.

COVID-19 restrictions, large governmental importations, and hurricanes Eta and Iota created significant headwinds to promotion and sales:

During the second semester of the year, all commercial activities were severely restricted due to the COVID-19 pandemic. The curfew was lifted in October 2020 and a new mechanism of weekly alerts was implemented, which limited travel and meetings by department and municipality based on local cases. Commercial activities began to resume little by little, but the large farmer gatherings critical to Semilla Nueva's promotion efforts were still prohibited. Several towns and municipalities also established their own restrictions. The continual and unpredictable churn of restrictions by week and by region significantly complicated completing even basic activities.

In addition to COVID-19, hurricanes Eta and Iota caused weeks of rain in northern and eastern Guatemala, with some regions inaccessible for months. Heavy rains and floods caused destruction of property, damage of bridges and roads, and loss of crops (Figure 4). According to the Guatemalan government, 49,652 hectares of maize were damaged, affecting 72,204 families[1].

Many of our demonstration parcels in northern Guatemala could not be harvested at all, and most harvests in eastern Guatemala were postponed until the end of December 2020 and the beginning of January 2021. Low prices also caused farmers in the southern coast to delay their harvests. Guatemala's white maize market is largely protected, but with the pandemic, the Guatemalan government approved importation of large amounts of maize from Mexico, which caused prices to drop by up to 50% in the second half of the year. Combined, these events made it far more difficult to promote and sell our seed. From July to December 2020, we only held 36 field days and events which trained 363 farmers. Over the year, we only reached 792 people in 54 field days, about 40% of our original 2020 goal.

[1] https://www.maga.gob.gt/wp-content/uploads/2021/01/resumen-etaiota20.pdf

Figure 4: Hurricanes Eta and Iota caused massive flooding. While some farmers rented boats to transport harvests to dry land, many lost their harvests to rot. Photos from Semilla Nueva's sales team in Northern Guatemala.

Responding to the pandemic and hurricanes, the sales team focused on calls, individual visits, promotion directly in agrodealers and small events and trainings:

Given the inability to host our normal events, the sales team focused on individual outreach. Using a new tracking system, our sales team tracked 934 calls to farmers and agrodealers and 1,127 individual visits. Calls and visits were used to monitor F3 performance, troubleshoot problems, and explore plans for purchasing seed the following year. In addition, the sales team held small events at agrodealers to promote to farmers directly during high sales periods as shown below. The team also worked with our distributors to expand the total number of agrodealers selling F3. In 2019, 128 agrodealers in 61 of Guatemala's 340 municipalities sold F3 in 2019. We expanded to 159 agrodealers in 67 municipalities in 2020. As mentioned in the Marketing and Farmer Intelligence section below, F3 is now sold in the agrodealers that sell nearly half of all seed sold in Guatemala—fan accomplishment due to our sales team's hustle and persistence.

SMS marketing and mini-trainings took place in Guatemala's highlands:

Guatemala's highlands have one of the highest rates of childhood stunting in the world and the lowest use of hybrid seed in Guatemala. Semilla Nueva's marketing team designed a new series of SMS messages focused on seed promotion as well as training on improved agricultural practices. Over the course of September to November, we sent 15,925 messages to 2,815 farmers. Mini-trainings focused on proper maize management and improved taste of F3 tortillas, tamales, and corn on the cob.

Figure 5: Direct promotion in agrodealers.

Figure 6: Farmer shows F3 ear (left) vs. ear from other low-segment seed (right); Semilla Nueva field technician shows yield of non-hybrid seed (left) vs. F3 (right).

Figure 7: Mini-trainings on proper maize management, crop nutrition, good agricultural practices, planting, and post-harvest practices.

Three factors contributed to decreased F3 performance for farmers: 1) problems in seed production caused lower germination rates and a higher number of abnormal plants, 2) environmental pressures caused a high number of deformed ears, a genetic problem that hadn't been seen since 2017, and 3) the material has lower yields in high temperature tropics— as mentioned in our previous reports.

Over the course of 2020, the sales team began detecting problems both with seed produced in 2019 and sold in early 2020, as well as some new seed produced in 2020. Fortaleza F3 normally provides higher germination rates (i.e., the percentage of seeds that sprout) than competitors, but several farmers noted that their F3 was sprouting slightly less than competitors. As mentioned in the previous *January-June 2020 Standard Report*, the seed production team finished a large quality control greenhouse in early 2020 and was able to do extensive testing and identify that only certain batches of seed had this problem. The sales team worked with distributors and agrodealers to cycle out this seed and replace it with seed with higher germination rates. Regardless, a large portion of this seed was sold. In all, Semilla Nueva received 11 complaints from farmers and agrodealers about the problem over the course of the year. The problem was also apparent in Semilla Nueva's economic impact evaluation.

Later in the cycle, farmers also began to complain about abnormal plants. F3 is a hybrid seed, and all plants in a field should be uniform. For a small portion of farmers, up to 10% of plants looked significantly different than the rest. These plants produced smaller ears, a contributing factor to lower harvests. This problem was ultimately linked back to quality control issues with Semilla Nueva's basic seed production and outgrowers as mentioned below in the seed production section. Combined, these problems can largely explain the decrease in yields that reduced the economic benefits for farmers. Luckily, both problems have solutions which can significantly decrease their occurrence in the future. These solutions are being implemented—but Semilla Nueva's brand did suffer some damage.

Fortaleza F3's genetics posed additional challenges. First, we have seen that some years, some F3 plants produce deformed ears with low harvests. This was last seen in significant levels in 2017, and then returned this year, especially in hotter regions. We suspect the problem only manifests in years with certain environmental pressures, as a kind of defense mechanism. Regardless, in some parcels it contributed to decreasing yields, although less than the two problems described above. Ear rot was also an issue for some farmers, as shown below. As mentioned in previous reports, Fortaleza F3 has lower yields than originally expected in high temperature tropics. This problem was first noted in 2018 and has contributed to slower sales growth in high temperature regions like the Southern coast, and eventually to decreasing sales in that region in 2020.

Figure 8: Ear rot (left) and ear deformation (right) presented in commercial plots during 2020 season.

Sales results reached 85% of our original 2020 goals--growing sales 37% over 2019:
Semilla Nueva sold 2,981 bags of F3, representing 85% sales of the original 2020-year forecast. While sales were on track to meet goals in July 2020, Hurricanes Eta and Iota heavily impacted eastern and northern Guatemala, the regions where most second semester sales normally take place. The hurricanes destroyed harvests and left lands flooded, preventing replanting. Without the COVID-19 crisis and the hurricanes, we our forecasted sales would have held.

Table 4: Historic and planned Fortaleza seed sold by region (bags sold).

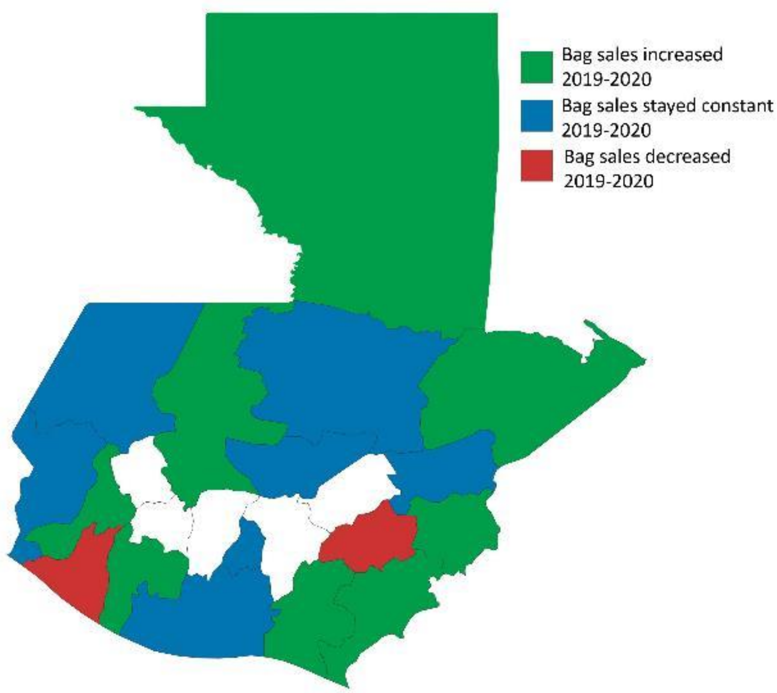
	2017	2018	2019	2020	
Region	**Total**	**Total**	**Total**	**Total**	**2019 vs 2020**
Southern Coast	34	583	826	712	-14%
Eastern	0	512	985	1556	58%
Northern	3	139	315	572	82%
Highlands	0	0	57	141	147%
Total	37	1234	2183	2981	37%

Looking at the data regionally, during 2020, eastern Guatemala represented 52% of F3 sales. This region, northern Guatemala, and the Guatemalan Highlands all showed growth. In contrast, sales on the southern coast were 14% less than 2019.

One of our biggest disappointments in 2020 was our inability to effectively execute our planned strategy to promote F3 as the seed that produces the best tortilla—a strategy which would be focused on the southern coast. While F3 has challenges competing economically with the more expensive seeds, it is universally recognized as producing better maize for home consumption. Our field team is enthusiastic about branding F3 grain as a premium product and the best maize for family consumption. While this strategy can't, by itself, generate enough sales to change Guatemala's seed sector, it is an additional tool to increase adoption and potentially change preferences in the market. For more commercial farmers, we planned large field days and taste testing events involving the whole farming family—but this strategy relied on in person events and was not possible due to both Tropical Storm Amanda and the COVID-19 pandemic. It is unclear the level to which this promotional strategy will be possible in 2021, given the COVID-19 situation.

Guatemalan agroecosystems and maize seed markets are diverse, and no seed is perfect in all areas. As mentioned in our Marketing and Farmer Intelligence section below, F3 does have a niche where farmers get acceptable yields and value the seed for the quality of tortillas it produces. This niche is difficult to target, because it consists of more conservative, poorer farmers who are difficult to contact. Semilla Nueva's growth will depend on continuing to target these farmers and regions and find creative ways to do promotion of a new product during a continued COVID-19 pandemic. (It is important to note that as of January 2021, Guatemala has not yet negotiated the purchase of any vaccine.) We continue to refine our sales team and strategy, including hiring sales technicians in areas of long-term growth and decreasing our presence in the southern coast.

In the long-term, success will depend on continuing to improve our strategies, staff, and execution—Semilla Nueva is shifting significant resources into R&D because the most important steps we can take to further increase farmer adoption is developing higher yielding biofortified seeds.



Department	2019	2020
Alta Verapaz	33	56
Baja Verapaz	0	10
Chiquimula	144	277
Escuintla	72	57
Huehuetenango	48	20
Izabal	44	94
Jalapa	123	77
Jutiapa	345	752
Peten	282	553
Quetzaltenango	80	274
Quiche	7	121
Retalhuleu	465	88
Sacatepequez	20	19
San Marcos	117	110
Santa Rosa	37	96
Suchitepequez	74	176
Zacapa	292	278
Total	**2183**	**3058**

Figure 9: Changes in sales 2019 vs. 2020 by Guatemalan department. Colors represent sales increasing by more than 30 bags, increasing by more than 30 bags, or staying within 30 bags.

SEED PRODUCTION

Summary:

- Several lots of seed produced in 2019 and 2020 showed problems with germination. These seeds were linked to seed produced in a location with high humidity, high rainfall, and a high-water table. Production in this region was discontinued. All new seed is being produced in regions which historically do not have these conditions.
- Over 5,000 bags of F3 will be ready for commercial sales and partnerships in 2021—but yields and profitability will be lower due to damage from Hurricanes Eta and Iota.
- New quality control systems were put in place to address the issues with out-of-type seed identified by the sales team.

All low germination seed was tracked to a single production location, which has been discontinued:

As mentioned in the Sales section and the *January-June 2020 Standard Report*, a significant portion of 2019 and 2020's seed production had low germination rates. Several lots of seed with germination rates below 85%, the level required for commercial sales, were donated to subsistence farmers. Semilla Nueva's production team evaluated the germination rates of seed produced in different locations and tested both initial germination rates as well as how different environments affected those germination rates over time. The seed produced in late 2019/early 2020 was grown in three locations: Caulotes, Chiquimula; San José La Máquina, Suchitepéquez, and Horcones, Chiquimula. We are evaluating seed germination with seed stored in four different environments: 1) Semilla Nueva's cold room (with controlled air temperature and humidity), 2) Semilla Nueva's commercial storage room (our current warehouse with naturally cool temperatures and low humidity), 3) Semilla Nueva's experimental center (with hot temperatures and high humidity), and 4) a blended condition of six months in the commercial storage room and then six months in the Semilla Nueva experimental center. The seed will be monitored for a year with results collected every three months. Results from the first six months are presented below.

Table 5: Preliminary results of F3 germination and seed quality study.

Region	Municipality, Department	Harvest Date (Month-Yr)	Batch	Environment	Seed Germination (%)		
					May-20	Aug-20	Nov-20
Eastern	Caulotes, Chiquimula	Mar-20	L-013A	Cold Room	97	98	96
Eastern	Caulotes, Chiquimula	Mar-20	L-013A	Comercial Storage Room	97	97	97
Eastern	Caulotes, Chiquimula	Mar-20	L-013A	Experimental Center	97	95	55
Eastern	Caulotes, Chiquimula	Mar-20	L-013A	Blended	97	96	96
Southern Coast	La Máquina, Suchitepequez	Mar-20	L-014A	Cold Room	97	96	98
Southern Coast	La Máquina, Suchitepequez	Mar-20	L-014A	Comercial Storage Room	97	97	95
Southern Coast	La Máquina, Suchitepequez	Mar-20	L-014A	Experimental Center	97	92	57
Southern Coast	La Máquina, Suchitepequez	Mar-20	L-014A	Blended	97	96	96
Eastern	Horcones, Chiquimula	Apr-20	L-15,16,17A	Cold Room	89	86	84
Eastern	Horcones, Chiquimula	Apr-20	L-15,16,17A	Comercial Storage Room	89	81	73
Eastern	Horcones, Chiquimula	Apr-20	L-15,16,17A	Experimental Center	89	61	21
Eastern	Horcones, Chiquimula	Apr-20	L-15,16,17A	Blended	89	82	75

Preliminary results showed that all low-germination seed was produced in a single region. Horcones, Chiquimula in eastern Guatemala is a site with high humidity, sporadic rains, and cloudy conditions during the seed harvest season, as well as heavy soils with a water table close to the surface. These conditions appear to have damaged seed during drying and harvest. The seed germination rates were lower initially and degraded more quickly than seed produced in other regions. These findings are important for choosing future production sites as well as for providing technical advising to other seed companies and governmental programs interested in producing F3.

The study was also important in evaluating the impact of storing well produced seed (seed from San José la Máquina and Caulotes) in high temperature and humidity settings. Seed produced in both areas maintained an excellent germination rate after three months of storage in high temperature and high humidity conditions (our experimental center in the southern coast), but the germination rate fell dramatically after six months of storage in such adverse conditions. This confirms that our sales team must ensure that distributors and retailers do not store seed for long periods in high humidity and temperature conditions, cycling seed out that has been in those conditions for too long.

Over 5,000 bags of F3 seed will be ready for the 2021 sales season, but increased planting areas will require us to concentrate our production geographically:
Five contracted farmers (outgrowers) planted 27 hectares between August and November 2020. Semilla Nueva maintained the same production supervision staff, but increased the area planted by 60% with respect to the 2019/2020 production season. New areas do not historically have the high humidity conditions during harvesting that negatively affected part of 2019 and 2020's seed production. Given the increase in seed production, the team decided to explore several new production sites, but in doing so increased workload and travel time for Semilla Nueva's production coordinator. Considering the anticipated growth needed for our future seed production, we will explore two strategic questions: 1) *Can we consolidate all our seed production in one region which offers both good seed yields and seed quality?* and 2) *Should we rent a small farm and produce all of our seed in-house?* Having one site would allow for a significant savings in travel costs and logistical complexity but would increase the risk that a single storm could damage all of our seed production.

Hurricanes Eta and Iota caused some loss of seed and increased production costs: Semilla Nueva's first productions sites are being harvested at the time of writing. While yields appear to be similar to 2019/2020, there will be at least slight losses. For plots that have not been harvested yet, there is evidence of a range of diseases that damaged plants and ears, as a consequence of the weeks of constant rain from tropical storms and then Hurricanes Eta and Iota which will result in lower yields and high seed discard (Figure 10). Overall, we anticipate a 15% decrease in seed production per hectare and a 35% cost increase due to additional pest control and fertilization.

To decrease the frequency of abnormal plants that the sales team reported, we put a more rigorous and thorough quality control system in place for our current seed production. We trained outgrower farmers to be more rigorous in identifying abnormal plants and eliminate all plants that seemed even somewhat abnormal. This process increased plant elimination from 4 to 9%, with some sites up to 13.5%--which contributes to the higher seed production costs mentioned above. In addition, the seed production team worked with the R&D team to further test and clean our parental seed on a consistent basis, which should reduce the need for these more intensive quality control practices in the long run.

Figure 10: Challenges of seed production in Jutiapa (eastern Guatemala). The crop was affected by foliar diseases, ear rot, and poor ear filling.

Overall, the seed production team faced substantial challenges, but they now have significantly more resources to address them. The greenhouse we opened in mid-2020 will allow for constant evaluation of our seed. The greenhouse made possible the germination studies we mentioned above, which will allow us to predict the amount of time seed can stay with retailers before it needs to be returned. Strengthening the R&D team will improve the management and quality of our parental seed. Overall, Semilla Nueva is facing the same challenges that face any small seed company—and our quality in our worst moments is comparable to that of local seed companies. By implementing improved systems, we will be able to gain a measurable and important competitive edge. Higher germination rates and cleaner seed does increase yields, and it is noticed by farmers. Winning in those areas will be a critical strategy to maintain F3 sales growth while we work to develop higher yielding biofortified seeds.

MARKETING – FARMER INTELLIGENCE

Summary:

- Semilla Nueva is more successfully targeting the poorest farmers and smallest farmers who buy commercial seed.
- Based on a survey of agrodealers who sold nearly half of the commercial seed in Guatemala, 87% of farmers who bought F3 are in our desired farmer segments, a slight improvement compared to 82% in 2019.
- Fortaleza has dropped from the second most recommended brand to the third. Poorer farmers who produce solely for home consumption are the happiest farmers using our seed. Grain size, color, and yields are the main reasons that more commercial farmers prefer other seeds. Farmers that choose Fortaleza value F3's taste, low price, resistance to storms and winds, and—interestingly for a small portion of farmers—the nutritional quality of the grain.
- Small farmers in Guatemala's western highlands, the most malnourished part of the country, gave F3 a perfect rating.
- These findings show that Semilla Nueva has two main focuses for the coming years:
    - Improve targeting, marketing, and accessibility of our seed for 1. poorer farmers with smaller land sizes who buy less seed volume and are generally more malnourished and happier with the seed, and 2. regions where these farmers are more prevalent.
    - Develop seeds with better grain appearance and/or with yields that are high enough to compensate for this issue.

Semilla Nueva surveyed the retailers who sell 47% of Guatemala's maize seed:
In August and September 2020, we surveyed 152 agrodealers in 16 of Guatemala's 23 departments and in all major maize producing zones. These agrodealers sold 56,054 bags of seed during the main 2020 planting season, representing 47% of the total maize seed market in Guatemala.

According to agrodealer surveys, Semilla Nueva's average customer is a smallholder farmer who buys a partial bag of seed:
70% of the F3 seed purchased was sold by the bag to farmers who bought an average of 2 bags of seed (88lbs, enough to plant 2 hectares). 30% of seed was sold by weight to farmers who purchased an average of 1/4 of a bag (11lbs or enough to plant 1/4 of a hectare). This is a critical distinction, although most of Semilla Nueva's volume is sold by bag to farmers who buy larger amounts, Semila Nueva's average customer is a smallholder farmer who buys far less than a bag primarily to produce grain for home consumption.

Agrodealers report a continued increase in seed purchased by the poorer farmers Semilla Nueva targets:
Surveyed agrodealers were asked which seed F3 customers would have purchased if it was not F3. They reported most farmers would have purchased the inexpensive, lower yielding low-segment seed only used by Guatemala's poorest farmers. When asked directly what kind of farmers buy F3, the vast majority of agrodealers said the poorest, low-segment farmers.

Table 6: Agrodealer survey: If your F3 customers had not purchased F3, what seed would they have purchased?

	2019	2020
Low-segment	53%	61%
Mid-segment	29%	26%
High-segment	18%	13%

Semilla Nueva's seed is becoming more geographically available and commercially accessible: Semilla Nueva's Fortaleza F3 seed was the 9th most sold seed, sold by 70% of the agrodealers surveyed (versus only 55% in 2019). The chart below shows the seeds most sold by surveyed agrodealers. Overall, high-segment seeds represented 47% of the sales volume in the agrodealers surveyed, medium-segment represented 27% of the seeds sold, and low-segment seeds represented 26% of seeds sold. Importantly, not all seed is sold through these specific agrodealers, who represent a large but not necessarily representative sample of the market. Semilla Nueva also surveyed the most commercial areas which sell a larger proportion of high-segment seed. A full breakdown is available as an appendix to this report.

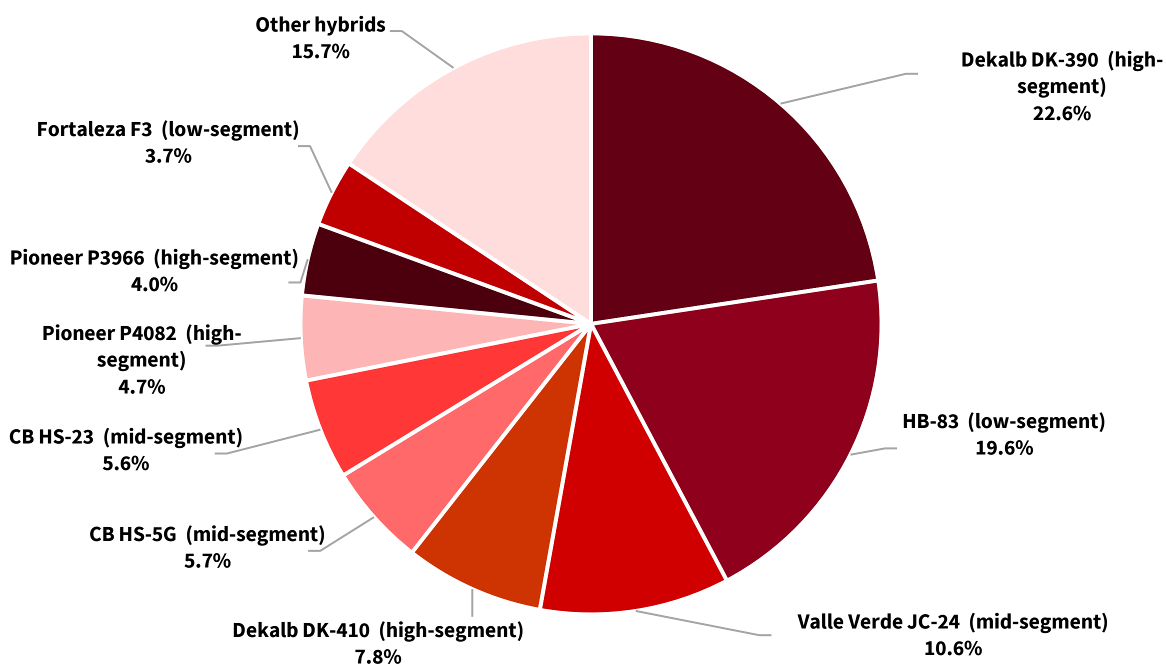


Figure 11: Market share by seed among surveyed agrodealers during the 2020 main planting season.

Semilla Nueva's marketing and farmer intelligence survey confirmed that most of Semilla Nueva's customers are smallholder farmers who consume most of their maize: In late 2020, Semilla Nueva surveyed 210 farmers who planted F3 in 2020 and 53 who planted in 2019 but didn't replant in 2020. Of the farmers who planted in 2020, 66% of farmers surveyed eat all or most of the maize they produce. Another 38% produce for home consumption but sell a larger volume. Only 2%

sold all their maize and did not consume it at home. Families had an average of 2.6 children at home, and 60% of farmers have children under five. 88% declared that maize was their primary crop.

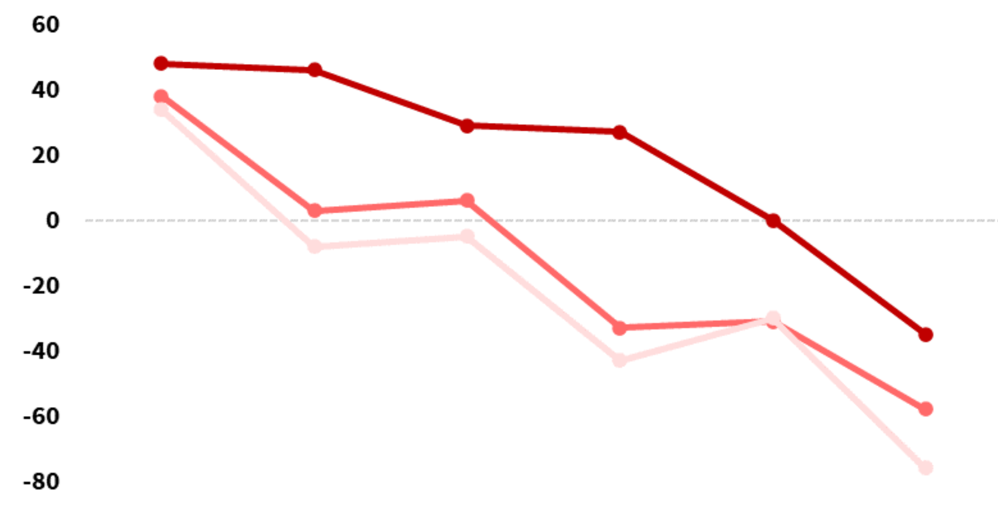
Grain size and grain color are the biggest market barriers for F3:
Of the 53 farmers who did not purchase F3 again, the vast majority cited problems with selling their product, especially due to grain size or grain color. This information is vital, because it shows the significant challenges we face due to the smaller and darker grain characteristic of protein biofortified maize.

Semilla Nueva asked the 210 farmers who planted F3 to name their favorite brand and then say what most mattered to them in a seed. The different answers give a strong sense of F3's market niche and the barriers that the next generation of biofortified seeds will need to overcome.
Many interesting potential trends can be pulled from the table below, but several are worth highlighting. Farmers always care about yield more than any other factor. Farmers who planted Fortaleza and see it at as their favorite brand have slightly different values than farmers who love other brands; they value low prices, the good taste of the tortillas, and recommendations from friends and family more than the average customer does. Interestingly, they are also the only customers who mention nutrition as a priority. One of Semilla Nueva's biggest challenges is that maize seeds with higher protein quality tend to have smaller and slightly darker grains, which do produce tortillas that are largely experienced as better quality. Semilla Nueva will need to simultaneously explore if maize taste and nutrition can overcome the market biases that currently exist, or if our breeding program must develop seeds which are either only biofortified with zinc and iron or improve the appearance of protein biofortified maize seeds.

Table 7: Favorite brand and favorite characteristics for 210 surveyed farmers.

	Total	Fortaleza	Dekalb	Valle Verde	ICTA	Pioneer
Favorite brand	210	42	52	44	15	19
%	100%	20%	25%	21%	7%	9%
What do they most value in their favorite brand?						
High yield	**41%**	26%	**58%**	**36%**	**40%**	**42%**
Grain size	**27%**	19%	23%	**34%**	**33%**	**32%**
Resistant to weather / insects / rot	21%	10%	25%	16%	27%	16%
Plant size / does not fall with the wind	19%	10%	21%	18%	27%	21%
Grain weight	16%	5%	15%	23%	20%	**37%**
Tried it before / I know it's good / quality	15%	19%	10%	7%	20%	21%
Sells easily / more market / well known	9%	2%	**29%**	2%	0%	0%
Grain color	8%	7%	10%	16%	0%	5%
Price / low-priced	7%	**14%**	2%	9%	0%	5%
Someone recommended it to me	5%	**17%**	2%	7%	0%	0%
Good flour / good taste / good tortillas	5%	**19%**	0%	5%	0%	0%
Yields without fertilizer	3%	5%	2%	5%	7%	0%
Better nutrition for my family	3%	**14%**	0%	0%	0%	0%
It is available / I find it everywhere	3%	2%	6%	2%	0%	5%
Other	6%	7%	4%	5%	0%	5%

Fortaleza drops from the second to third most recommended seed brand: Using the net promotor score methodology, farmers were asked how highly they would recommend different seed brands to a friend or family. These numbers are then calculated to a score between a perfectly recommended brand (100) and universally unrecommended brand (-100). As shown below, the biggest two transnational seed companies which offer the most expensive and highest yielding seed were the most recommended in Guatemala. Semilla Nueva dropped to third behind international brand Pioneer, but stayed slightly ahead of Valle Verde, Guatemala's largest national seed company. The difference in the scores between 2020 vs. 2018-9 may be due to an important factor: This was the first year that the NPS survey mostly surveyed random Semilla Nueva customers, vs. farmers that our sales team knew had purchased seed. Average farmers may be more positive about seed brands in general and may have a more mixed perspective on Semilla Nueva's seeds vs. farmers who our sales team knew personally. Another possibility is that experiences of grain penalties or atypical plants may have caused a drop in the brand's perception. Regardless, maintaining the third highest perception among all seed brands even amidst the problems the seed faced in 2020 is a strong indicator of the quality work of our field team as well as the important truth that other brands also have marketing challenges.



	Dekalb	Pioneer	Fortaleza	Valle Verde	Cristiani CB	Costa Sur
NPS 2020	48	46	29	27	0	-35
NPS 2019	38	3	6	-33	-31	-58
NPS 2018	34	-8	-5	-43	-30	-76

Figure 12: Net Promoter Score (NPS) of Guatemalan seed brands.

Beyond the overall tendencies of different brands, there were also several other interesting results of the study.

- Fortaleza had a far higher NPS score for farmers who consume all their maize (43) vs farmers who sell some (NPS 24) or most (NPS 22) of their grain. Selling biofortified maize is a challenge for farmers. The smallest, poorest farmers producing for home consumption are the happiest with F3.
- NPS was high in northern Guatemala (NPS 34) and eastern Guatemala (NPS 24). It was lowest in southern Guatemala (NPS 16) and received a perfect score in the Guatemalan Highlands (NPS 100). While sales grow more slowly in the highlands due to less tradition of buying seeds and significantly smaller land holdings, it is the area where the seeds are best received.

- As expected, farmers who normally use high tier seed had a much lower opinion of Fortaleza (NPS 2) than farmers who used a mid-segment seed normally (NPS 27) or used Fortaleza normally (NPS 52). This is important because it means there is a loyal customer base, and there is a possibility of converting more mid- and low tier farmers if the issues related to yields and grain penalties are resolved.

Farmer field days, individual interactions with field technicians, and agrodealers are the most important mediums to reach farmers. Radio and billboards were not memorable, but SMS and WhatsApp messages did influence roughly 5% of customers:
Of farmers who purchased seed, most learned about the seed from agrodealers, field technicians or friends. The vast majority did not remember observing any F3 mass marketing. 4% did mention phone calls by the sales team as being a significant motivator for purchasing seed. 3% said SMS messages and 2% said WhatsApp messages were memorable and influenced their decision to buy seed. No farmers mentioned the relatively expensive radio ads or billboards. Semilla Nueva's sales team has always advocated that field days and agrodealers are the most important means to reach farmers, and the data seems to support this conclusion. At the same time, Semilla Nueva only spent $400 on SMS messages during 2020 and had no additional costs for WhatsApp Messages (other than staff time to write them)—and these two mediums were important for roughly 5% of Semilla Nueva's customers in 2020.

Behavior change strategy for grain penalties in process:
In mid-2020, one of our major donors contracted a Guatemalan social marketing company to generate a behavior change campaign to decrease the penalties imposed on farmers for darker and smaller grain. Semilla Nueva invested heavily in the process, providing literature, data, leading visits throughout Guatemala, and participating in numerous work sessions. The company is currently preparing to present their recommendations at the beginning of February 2021.

COLLABORATIONS – PUBLIC POLICY

Summary:

- We believe the most cost-effective and politically feasible way to decrease nutritional deficiencies in the Guatemalan population is by incentivizing seed companies to switch to biofortified seeds and sell them to farmers at reduced prices. To test the idea, Semilla Nueva has partnered with Guatemala's largest national seed company, Valle Verde, to design and pilot an incentive program. Valle Verde began seed production and is preparing to launch sales of Fortaleza F3, under their own name, in April of 2021.
- A second option for public policy involves government distribution of small amounts of biofortified seed to Guatemala's poorest – essentially subsistence – farmers. In May 2020, Semilla Nueva launched a program to provide our biofortified seed directly to 1,878 farmers who could not afford to buy it. The program was a success, increasing farm families' food security and incomes and generated valuable data on the impact of hybrid seed use by subsistence farmers. The program was expanded in October 2020 to 3,400 additional farmers, but unfortunately, they all lost their plantings due to Hurricanes Eta and Iota.
- A new coordinator for our public policy work started in August. Semilla Nueva's began to hold targeted meetings with government officials and gave over a dozen radio, TV, and printed press interviews. This contributed to the Guatemalan Ministry of Agriculture announcing two new programs: 1) A national reserve of maize and beans for emergencies using biofortified seeds, and 2) A seed donation program which would also begin to use biofortified seeds. Both programs are scheduled to launch in 2021 but may launch later given the complicated political situation in Guatemala.

Guatemala's largest national seed company signed on to pilot our seed incentive program. Seed will be ready for 2021 sales:

To test the policy mechanism that we believe could scale the use of biofortified seed in Guatemala, Semilla Nueva began a pilot of the program with Guatemala's largest national seed company, Valle Verde. Controlling between 10-15% of Guatemala's seed market, Valle Verde is the third or fourth largest maize seed provider in Guatemala, depending on the year. Valle Verde's sales are only behind those of the world's leading transnational seed companies. They are also the most important company in the mid-segment of the market. They have a strong reputation for being professional and technically skilled and have earned their position in the market through decades of consistent quality.

Semilla Nueva spent three months in negotiations with Valle Verde's owners. They were familiar with our biofortified seed, Fortaleza F3, having purchased parental seed from the Guatemalan government, produced commercial seed, and planted it with several farmers over the course of 2018-2019. Semilla Nueva asked Valle Verde a simple question: *How much of a financial incentive would you need to produce and sell Fortaleza F3, under your branding, at a price that would be very advantageous to farmers*? Semilla Nueva worked with Valle Verde to create an agreement that would be the model for how we believe the Guatemalan government should work with seed companies. The agreement established sales goals, margins, means of verification, the amount of the incentive, and agreements for both quality control and resolving disputes. Thanks to support from the Innocent Foundation and the Light a Single Candle Foundation, Semilla Nueva quickly gained access to sufficient new funding to be able to commit to the incentive to Valle Verde for their 2021 sales.

In October 2020, Semilla Nueva signed an agreement with Valle Verde and sent enough parental seed to allow it to produce 1,000-1,500 20kg bags of commercial seed. Semilla Nueva's production team has met frequently with Valle Verde's staff during the seed planting and production process, and their sales are expected to begin in April 2021. Valle Verde was also emphatic that incentives could decrease substantially if higher yielding biofortified seeds could be developed—and that they would be interested in partnering in that endeavor as well.

Semilla Nueva's 2020 COVID relief program reached 1,878 families. It showed that providing biofortified seed to poor subsistence farmers can raise their incomes and improve their food security:
In May 2020, Semilla Nueva provided non-commercial seed to two farming associations (see *January-June 2020 Standard Report*). The primary goal was to use seed that Semilla Nueva normally cannot sell (either small seed which is a byproduct of seed processing or low germination seed) to help Guatemala's most vulnerable farmers during the COVID-19 crisis. Second, we sought to resolve an important doubt expressed by leaders in the Guatemalan Ministry of Agriculture: *Do poor subsistence farmers need extensive training, fertilizer, and other inputs to make effective use of improved seeds—or can providing seed with no additional inputs make a significant impact?*

Figure 13: Alex, a farmer from the Quiche department planted F3 in May 2020. Normally his family only produced enough maize for eight months of the year. In October 2020, he harvested enough maize to store a year's food supply for his family and sell some in the market.

Both goals were accomplished. As explored in the Impact Evaluation section, economic analysis and side-by-side harvests of 20 farmers showed that they increased their incomes by 132%. The program was most successful in eastern Guatemala, where yields increased 34%. As a normal byproduct of seed processing, Semilla Nueva will have an increasing amount of non-commercial seed every year, so this program can continue to reach thousands of families annually with little additional cost.

Simultaneously it will generate evidence of the impacts on income and nutrition that simply providing biofortified seed can have for Guatemala's poorest farmers.

In October of 2021, Semilla Nueva expanded its COVID relief program by providing seed to 3,400 families through two farming associations. Unfortunately, Hurricanes Eta and Iota destroyed farmers' maize plantings and made replanting impossible:
Semilla Nueva continued to work with ASIDESAFAV, an association from our May COVID project, as well as a new farmer association, FEDECOVERA. Both are in the department Alta Verapaz, an area where farmers plant maize a second time in the months of October and November. Semilla Nueva signed new agreements with the two associations and provided 34,000 lbs. of seed as well as training. The associations then distributed the seed to partnering farmers. Hurricane Eta and Iota had their worst impacts in this region, with rains and flooding lasting for most of a month, destroying nearly all maize crops in the region. Tens of thousands of families lost their harvests (see Sales section above for photos) and areas remained flooded for long enough to make a new planting impossible. Semilla Nueva will work with these associations to assist farmers in May 2021.

Figure 14: Semilla Nueva donation to FEDECOVERA in Alta Verapaz (northern Guatemala).

Semilla Nueva launched a public awareness campaign for biofortified seeds, and the government launched two initiatives to bring biofortified seeds to thousands of families in 2021:
Semilla Nueva hired a coordinator for strategic alliances in August 2020. Working with the political consultant we hired in March 2020, the team launched an awareness campaign that included eight radio interviews, two TV interviews, and articles in four of Guatemala's newspapers. These interviews often included members of other leading institutions who advocate for the use of biofortified crops by the Guatemalan government. Semilla Nueva largely shifted its social media from focusing on US donors to focusing on Guatemalan public opinion, launching new videos with farmer testimonials which reached tens of thousands of views and engagements in Guatemala City. The team also continued meetings with influential organizations and key decision makers, including the Guatemalan Minister of Agriculture, several Vice Ministers of Agriculture, Secretary for Food and Nutritional

Security, the Vice Minister of Economy, the head of the congressional committee on food security, and multiple meetings with the director of the Guatemalan Institute for Agricultural Sciences and Technologies. Meetings have shown the Guatemalan government to be interested in using more biofortified seeds in their programs, but more inclined to use traditional, non-market-based mechanisms—and hesitant or reserved about a seed incentive program in the near-term.

In September 2020, the Guatemalan Minister of Agriculture, announced in the Guatemalan government's national economic reopening event that a new national grain reserve will be created[2]. The reserves will purchase 5 million pounds of maize and beans per year and distribute them in emergencies or poverty reduction programs. All 5 million pounds will be biofortified. Semilla Nueva was involved in several consulting initiatives and assisted in designing the primary proposals spearheaded by the World Food Programme. We also assisted the consulting team hired to develop the technical proposal. The details of the program are still being designed but may be led by the World Food Programme with funding from the Guatemalan Ministry of Agriculture as early as April 2021.

Further, the Guatemalan Ministry of Agriculture signed an agreement with the Institute of Agricultural Sciences and Technologies to produce and distribute both biofortified and conventional seeds for three years. Final details are in negotiation, but it has the potential to bring biofortified seeds to 5-15,000 families a year, starting in 2021 or 2022.

Overall, these positive steps could significantly increase the number of families using biofortified maize seeds in 2021 and beyond. More importantly, they lay the foundation necessary to achieve the kinds of public policies and partnerships that would use biofortified maize to decrease Guatemala's most urgent nutritional deficiencies.

[2] https://www.maga.gob.gt/programas-de-reactivacion-economica-beneficiaran-a-familias-agricultoras/

RESEARCH AND DEVELOPMENT

Summary:

- A new seed with high zinc, iron, and protein quality and 8-17% higher yields (compared to F3) will be provided to 100 farmers for pre-commercial trials in 2021. Pending results, a full commercial launch is planned for 2022.
- Semilla Nueva purchased all necessary equipment to launch a laboratory with the capacity to analyze thousands of new seeds every month.
- A new crop breeder was hired in September of 2020, and a new breeding technician was hired in June. With a full-time team of four, Semilla Nueva is now able to expand our breeding field work and launch our new nutrition lab in February-March 2020.
- Semilla Nueva formed a technical advisory board, with four former executives and researchers from the world's best seed companies. They provide technical advice on breeding strategy, seed production and other related areas.
- With the expanded team, technical advisers, and lab equipment, Semilla Nueva will be able to test our new breeding strategy in 2021. We have integrated several approaches to develop new seeds with much higher yields, improve grain size in our high protein quality seeds and explore developing seeds for the higher segment of the market with lower protein quality but much better grain appearance. Feasibility of each of these paths will be determined over the course of 2021.

Fortaleza F5--a seed with higher protein quality and yields, and similar levels of zinc and iron is on track to reach approximately 100 farmers in 2021 and if successful, be launched commercially in 2022:

A new seed with similar levels of zinc and iron, a better protein profile, and 8-17% higher yields is in production for a pilot launch with select farmers in 2021. Pending results, Fortaleza F5, could be a replacement for our current seed, Fortaleza F3 with significantly more potential for adoption by farmers due to its higher yields. As shown below, in 2020 trials, Fortaleza F5 had significantly higher yields than the most popular seeds in the low and mid-segment (HB-83 and Valle Verde's JC 24), but still was not competitive with the most competitive seed in the high-segment (Monsanto's DK390).

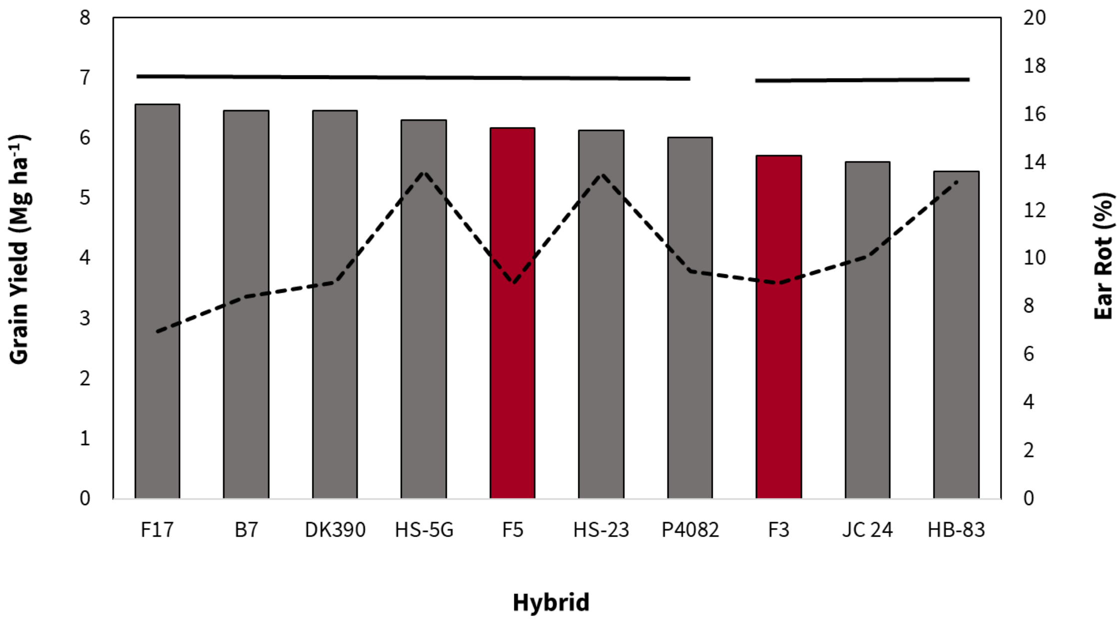


Figure 15: Guatemala evaluation trials, 2020 rainfed season. Results from five locations. Bars are yields from commercial hybrids, including the most sold hybrid in the high segment (DK-390) and low segment (HB-83). Dotted line corresponds to ear rot.

Semilla Nueva purchased remaining equipment to launch our lab for protein quality with Central America's leading nutrition research institute and launch an in-house lab for determination of zinc and iron in February/March of 2021:
Thanks to technical assistance from the USDA-ARS research station in Ames, Iowa, Semilla Nueva purchased the remaining equipment to launch a laboratory to analyze the amino acid levels (protein quality) in maize samples. The equipment has been delivered to the Institute of Nutrition of Central America and Panama (INCAP), Central America's leader in nutritional analysis, studies, and policy recommendations. The methodology utilizes live bacteria and requires a sterile laboratory. INCAP has suitable facilities and will use Semilla Nueva's equipment and provide analysis to Semilla Nueva at cost, after validating the methodology in March of 2021. These processes were significantly delayed due to the COVID-19 pandemic as explained in our previous report.

Thanks to assistance from the Swiss Re Foundation, Semilla Nueva was also able to obtain a new piece of lab equipment for analyzing the zinc and iron levels in maize samples. The machine, called an HD-XRF, is a new class of X-Ray fluorescence which should provide significantly higher accuracy than the current models used by researchers worldwide. Given that the model only requires grinding maize samples and then inserting them into the equipment, Semilla Nueva will begin conducting its own analysis of zinc and iron in our warehouse outside Guatemala City. Our current plan is to analyze 5,000 samples a month by the end of 2021. At that capacity, regardless which breeding approaches prove successful, we will have the ability to check nutritional levels at scale and build the backbone of long-term efforts to develop seeds for Guatemala and eventually Sub-saharan Africa.

PhD breeding director hired; he is expanding Semilla Nueva's breeding efforts:
Dr. Fredy Longo joined the team in September 2020 following a career in crop breeding for the Guatemalan government and vegetable breeding and sugar cane breeding for the Guatemalan private sector. Dr. Longo has developed new breeding initiatives in the past as well as designed and created new laboratories. With a new breeding technician also hired, Semilla Nueva began several new programs to develop and validate new biofortified seeds more quickly. These initiatives include continuing Semilla Nueva's backcross program to develop new seeds with yields similar to the best seeds in the market, a new program to improve the grain size and color of protein biofortified maize, and a new initiative to explore biofortification without higher protein quality levels. With the new laboratory in place, initial results for these various initiatives will be ready by the end of 2021.

Figure 16: Dr. Fredy Longo begins initial testing of HDXRF while awaiting lab construction.

Advisory board launched with industry experts:
Semilla Nueva's board of directors worked with staff to launch a new advisory board. Semilla Nueva has knowledgeable, local staff in breeding and seed production, but lack access to the technical support and expertise found at the world's leading seed companies and universities. Semilla Nueva board member Dr. David Morgan, former President of Syngenta North America, recruited Dr. Ray Riley, former Head of Computational Biology, Traits Research, and Global Corn Product Development at Syngenta as well as Dr. Ed Attema, former Head of Seed Operations, Production &Supply, at Syngenta. Ray, in turn, recruited Dr. Bob Merrill, former Director of Information Management at Pioneer. The advisory board has had numerous meetings with staff on the direction and short-term strategy of the breeding program, inventory management systems, and quality control systems. It is difficult to overstate the importance of this new system of technical support and guidance, especially as Semilla Nueva prioritizes seed development as our highest organizational priority.

Semilla Nueva is making breeding our most important focus area for 2021:
As is evidenced throughout this report, as well as Semilla Nueva's newly launched three-year plan, there is potential to scale farmer adoption of biofortified seeds initially through Semilla Nueva's sales

and in the long-term through policy. Significant increases in adoption will require better biofortified seeds. Semilla Nueva has some potential for sales growth with Fortaleza F3, and should have more with Fortaleza F5, the new seed we plan to launch in 2022. Combined with government efforts and our own policy pilot, these two seeds may be able to reach more than 25,000 families annually. Reaching more than 100,000 families in Guatemala and expanding to sub-Saharan Africa will require some combination of higher yielding biofortified seeds and biofortified seeds with improved size and color. Semilla Nueva has several approaches to improve the development of seeds with these characteristics—and there are additional approaches which could be opened with additional funding. Semilla Nueva will be able to test these different approaches in 2021 thanks to efforts during 2020 to develop critical infrastructure, including lab equipment, staff, advisers, and the collection of hundreds of thousands of seeds ready for testing.

Agronomic biofortification work continues, with second test harvested:
Agronomic biofortification involves applying zinc fertilizer to maize plants to increase the amount of zinc in their grain. Semilla Nueva could package zinc fertilizers with seed to further increase the nutrition of farmers' grain. A second round of tests were launched in May 2020 to begin testing commercial doses of foliar applications of zinc. Five large plots were sprayed twice with zinc fertilizer and grains were collected in treated and untreated areas. Harvested samples will be sent for nutritional analysis. If results are positive, a final commercial trial with farmers is planned during the 2021 main planting season. While Semilla Nueva does not have plans currently to begin selling zinc fertilizer, it could provide an important complimentary strategy for the new seeds we are currently developing.

DEVELOPMENT – FINANCE

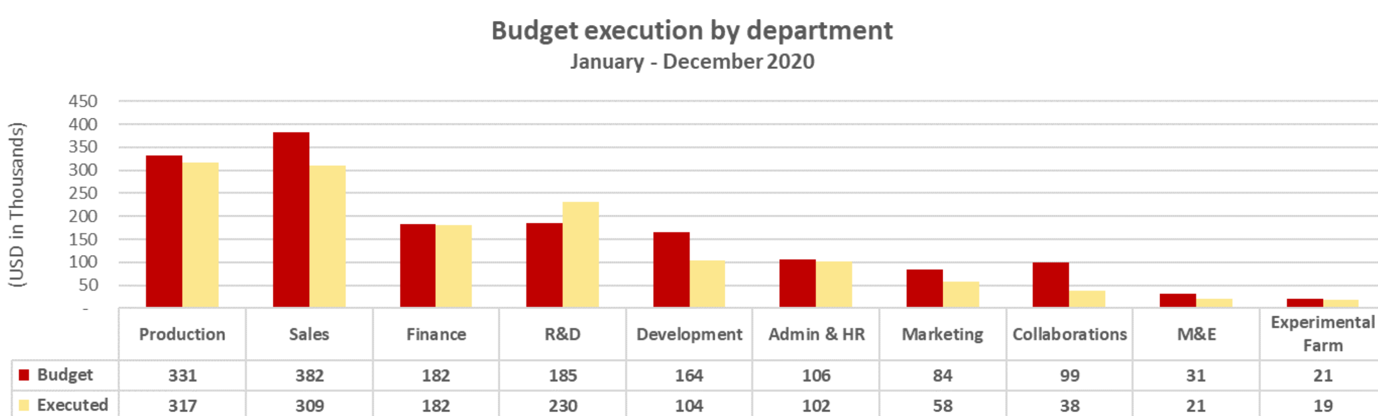
Summary

- Semilla Nueva has been supported by renewals from several of our longest-standing donors and a new grant from the Light a Single Candle Foundation.
- Cost saving practices allowed Semilla Nueva to spend only 87% of its budget. Additional funds are being moved to 2021 to allow for a significant expansion in R&D.

Cartier Philanthropy, Light a Single Candle Foundation, Conservation Food and Health, the International Foundation, Miracles in Action, and the Carson Foundation all renewed funding for Semilla Nueva; Innocent Foundation began a grant to Semilla Nueva:
Semilla Nueva was supported by a total of $362,000 in grant renewals in the second semester of 2020 and a new three-year program with the Innocent Foundation. We are enormously thankful. Most of these funds were provided as unrestricted grants. Semilla Nueva released a new three-year plan with budgets and milestones, and new donors all agreed to accept our bi-annual standard report and grant-specific financial reporting. Unrestricted grants and standardized reporting have allowed us to focus on better implementation, increased impact evaluation, more thorough reports, and more strategic planning rather than to the writing of multiple individual reports. For all the organizations who have moved to unrestricted funding and the acceptance of our standard reports, we appreciate you immensely. You are the future of international development.

Semilla Nueva's end of year grassroots fundraiser was also a major success:
Combining several Zoom events, an online fundraising page, matches from Miracles in Action, the Carson Foundation, GLG, and every member of our board of directors, Semilla Nueva raised over $130,000 in our end of year events. We are incredibly proud and thankful to all of you!

2020 budget vs actual
Semilla Nueva's 2020 budget was $1,585,462. Over the course of 2020, we executed $1,380,260, or 87% of the budget. This cost saving allowed us to move $205,000 of our budget to 2021.



	Production	Sales	Finance	R&D	Development	Admin & HR	Marketing	Collaborations	M&E	Experimental Farm
Budget	331	382	182	185	164	106	84	99	31	21
Executed	317	309	182	230	104	102	58	38	21	19

Figure 17: Semilla Nueva's budget vs. execution (January – December 2020).