the good growth plan

The Good Growth Plan Progress Data - Productivity 2015

Make crops more efficient

syngenta

1. Summary

Syngenta is committed to increasing crop productivity and to using limited resources such as land, water and inputs more efficiently. Since 2014, we have been measuring trends in agricultural input efficiency on a global network of real farms.

The Productivity 2015 dataset shows aggregated productivity and resource efficiency indicators for two crop seasons, 2014 and 2015, where available. The data has been collected from more than 3,600 farms grouped in 172 clusters and covers 21 different crops in 42 countries[1]. The data was collected, consolidated and reported by Market Probe[2], an independent market research agency.

Farms are grouped in clusters, which represent a crop grown in an area with homogenous agro-ecological conditions and include comparable types of farms. The sample includes reference and benchmark farms. The reference farms were selected by Syngenta and the benchmark farms were randomly selected by Market Probe within the same cluster. Data collection was carried out by Market Probe using a structured questionnaire and face-to-face interviews with participating growers. Data was collected on the usage of inputs, such as crop protection products, chemical fertilizer, seeding rates, labor hours, machinery usage hours, and marketable crop yield on a per hectare basis.

2. Metadata

Description of the dataset	The dataset includes 2014 baseline data and 2015 progress data for agricultural efficiency indicators for 3,600 farms in selected agro-ecological zones and market segments in 42 countries in Europe, Africa, Latin America, North America and Asia.
Date of first publication	April 23, 2015
Date of last update	August 2016
Date of next update	March 2017
Frequency of updates	Periodically
Reporting period	October 1, 2013 – September 30, 2015
License for re-using the data	The contents of this dataset and all supporting documentation are licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.

[1] The data set excludes data from the USA

[2] http://marketprobeagricultureandanimalhealth.com/

Text to use when citing the data	The Good Growth Plan Progress Data - Productivity 2015
URL to use when citing the data	www.goodgrowthplan.com
Geographic coverage	Algeria; Argentina; Australia; Bangladesh; Belgium; Brazil; China; Colombia; Costa Rica; Ecuador; Egypt; France; Germany; Guatemala; Honduras; Hungary; India; Indonesia; Italy; Ivory Coast; Japan; Jordan; Kenya; Malaysia; Mexico; Morocco; Netherlands; Pakistan; Paraguay; Peru; Philippines; Russia; South Africa; Spain; Tanzania; Thailand; Ukraine; United Kingdom; Venezuela; Vietnam; Zambia
Data language	English
Key words	input efficiency; crop productivity; agriculture; The Good Growth Plan
Subject	Agricultural input efficiency
Copyright year	2016
Copyright holder	Syngenta AG

3. Structure of the data

Data sets are at territory-, country-crop-, and cluster-level.

Variable name	Definition	Unit	Type of data
ReportingYear	Syngenta definition of reporting year for non-financial indicators		String
Region	Syngenta definition of region		String
Territory	Syngenta definition of territory (sub-region)		String
Country	Country		String
Crop	Crop		String
rf2014	Number of reference farms in reporting year 2014	Farms	Numeric
bf2014	Number of benchmark farms in reporting year 2014	Farms	Numeric
rf2015	Number of reference farms in reporting year 2015	Farms	Numeric
bf2015	Number of benchmark farms in reporting year 2015	Farms	Numeric
farms2014	Number of reference and benchmark	Farms	Numeric

	farms in reporting year 2014		
farms2015	Number of reference and benchmark farms in reporting year 2015	Farms	Numeric
clusters2014	Number of clusters in reporting year 2014	Clusters	Numeric
clusters2015	Number of clusters in reporting year 2015	Clusters	Numeric
Comment	Comment on changes from previous reporting year		String
Cropdetail	Sub-crop		Categorical
SmallholderCluster	Farms are defined as smallholder farms		Categorical
SmallholderPercent	Percentage of farms in cluster that are smallholders	%	Numeric
AreaSizeMin	Minimum field size	hectares	Numeric
AreaSizeAvg	Average field size	hectares	Numeric
AreaSizeMax	Maximum field size	hectares	Numeric
CropSizeMin	Minimum crop size in hectares	hectares	Numeric
CropSizeAvg	Average crop size in hectares	hectares	Numeric
CropSizeMax	Maximum crop size in hectares	hectares	Numeric
FarmSizeMin	Minimum farm size in hectares	hectares	Numeric
FarmSizeAvg	Average farm size in hectares	hectares	Numeric
FarmSizeMax	Maximum farm size in hectares	hectares	Numeric
ClusterDescription	Description of farmers in cluster	hectares	Numeric
ClusterID	Unique cluster identifier		String
AvgLandEfficiency	Average land efficiency as marketable crop yield	tons per hectare	Numeric
AvgPesticideApplicationEfficiency	Average number of pesticide applications per metric ton of marketable crop yield	applications per ton	Numeric
AvgNitrogenEfficiency	Average amount of nitrogen equivalents in kg per metric ton of marketable crop yield	kg per ton	Numeric
AvgPhosphorusEfficiency	Average amount of phosphorus equivalents in kg per metric ton of marketable crop yield	kg per ton	Numeric
AvgPotassiumEfficiency	Average amount of potassium equivalents in kg per metric ton of marketable crop yield	kg per ton	Numeric
AvgSeedEfficiency	Average amount of seed in kg per metric ton of marketable crop yield	kg per ton	Numeric
AvgPesticideEfficiency	Average amount of crop protection active ingredients in kg per metric ton of	kg per ton	Numeric

	marketable crop yield		
AvgHerbicideEfficiency	Average amount of herbicide active ingredients in kg per metric ton of marketable crop yield	kg per ton	Numeric
AvgFungicideEfficiency	Average amount of fungicide active ingredients in kg per metric ton of marketable crop yield	kg per ton	Numeric
AvgInsecticideEfficiency	Average amount of insecticide active ingredients in kg per metric ton of marketable crop yield	kg per ton	Numeric
AvgIrrigationWaterEfficiency	Average amount of irrigation water in liters per metric ton of marketable crop yield	liters per ton	Numeric
AvgLaborEfficiency	Average amount of labor in manhours per metric ton of marketable crop yield	hours per ton	Numeric
AvgMachineEfficiency	Average amount of machine hours per metric ton of marketable crop yield	hours per ton	Numeric
AvgSyngentaShare	Rate of adoption of Syngenta offer	%	Numeric

4. Background and methods

The main objective of the farm network is to monitor progress on Syngenta's commitment to increase crop productivity and resource efficiency. This is done by measuring performance in output-input ratios against set targets on real farms for selected crops and market segments relevant to Syngenta's commercial strategy. Syngenta considers a real world situation and takes into account preferences and decisions made by its customer farmers. An improved understanding of what works locally to increase productivity sustainably will help the company improve its solutions that are tailored to the geography and needs of the rural communities.

4.1. Description of the farm network

The farm survey is designed as a longitudinal study that involves repeated observations of crop output-input ratios over several years on the same farms. Farms are grouped into clusters, which include similar farm types and represent a crop grown in an area with similar agro-ecological conditions. The reporting scope (countries, crops, customer segments) is determined and reviewed annually by Syngenta in line with its commercial strategies.

The sample includes reference and benchmark farms. The reference farms were selected by Syngenta and the benchmark farms were randomly and independently selected by Market Probe within the same cluster.

The countries in scope have established targets which were baselined in 2014 and have to be met in 2020.

4.2. Sources of data

The data were generated by the respondent reference and benchmark farmers who measure and report on their input use and crop outputs over the respective crop season.

Data	Data source	Data processing
Farm-level data for reference and benchmark farms in Algeria, Argentina, Australia, Bangladesh, Belgium, Brazil, China, Colombia, Costa Rica, Ecuador, Egypt, Guatemala, Honduras, Hungary, India, Indonesia, Italy, Ivory Coast, Japan, Jordan, Kenya, Malaysia, Mexico, Morocco, Pakistan, Paraguay, Peru, Philippines, Russia, South Africa, Spain, Tanzania, Thailand, The Netherlands, Ukraine, Venezuela, Vietnam, Zambia	Market Probe[3]	Market Probe
Farm-level data for reference farms in France	Datagri[4]	Market Probe
Farm-level data for benchmark farms in France	Market Probe	Market Probe
Farm-level reference data for farms in the USA	Syngenta	Syngenta
Cluster-level benchmark data for farms in the USA	– USDA/NASS crop yields – USDA/ARMS crop input data – USDA/Farm & Ranch Irrigation Survey – USDA/NRCS soil loss data – State Extension crop budgets – USDA/NASS crop acreage Calculation of FTM metrics (Field to Market – The Alliance for Sustainable Agriculture www.fieldtomarket.org)	Syngenta
Farm-level data for reference and benchmark farms in Germany	Syngenta	Market Probe
Farm-level data for reference and benchmark farms in the UK	Syngenta	Market Probe
Pesticide active ingredient concentration	Homologa – The Global Crop Protection Database[5] Label information from internal sources (e.g. regulatory functions) or internet search	Market Probe
Smallholder definitions based on farm size	Syngenta	Market Probe

[3] http://www.marketprobeagricultureandanimalhealth.com/
[4] http://www.datagri.com/gestion/front/main/
[5] www.homologa-new.com

4.3. Data collection tools and process

Sample sizes for each cluster were determined in order to measure significant increases in crop efficiency over time. These were determined by Market Probe based on target productivity increases and assumptions regarding the variation of yields in each cluster. The smaller the expected increase, the larger the sample size needed to measure significant differences over time. Variations within clusters were based on previous research from the countries. Additionally, growers were also organized into clusters as a means of keeping variances under control, as well as distinguishing between growers in terms of crop size, region and technological level.

- A minimum sample size of 20 interviews per cluster is needed. The minimum number of reference farms is 5 of 20. The optimal number of reference farms is 10 of 20 (balanced sample).
- For results to be statistically significant when assessed over time, the minimum and optimum sample sizes need to be determined based on target increase and yield variation in each cluster.

Reference farm sign-up was organized through Syngenta's commercial organization in the countries. Reference grower characters were used to describe a cluster-specific profile, and based on which Market Probe independently and randomly selected comparable benchmark growers to provide a control group within each cluster.

The farm questionnaire was developed jointly by Syngenta and Market Probe. As each crop requires different practices and has different indicators, the final questionnaire was therefore split into crop modules. The master questionnaire was translated into local languages, which were reviewed and approved. The questionnaire covered: Farm activities (e.g. crops grown), soil management and safe-use practices, detailed use of chemical fertilizer, pesticide quantity by application and pest pressure, seed variety and seeding rates, labor and machinery hours, irrigation water use, abiotic stresses (such as heavy rain, cold or lack of rainfall), crop yield, harvest time, post-harvest losses, crop sales and prices.

Data collection took place according to the planting and harvesting times in each cluster. The first section of the questionnaire was administered during the crop season. The second section was administered after the harvest. Per respondent, information for up to two cultivation areas (e.g. plots, fields) was collected. The farmer interviews were conducted face-to-face in the local language by Market Probe interviewers using structured questionnaires. Respondents were introduced to the objectives of The Good Growth Plan and, if necessary, trained on recording input use and crop outputs. The Local help desk support was provided by Market Probe throughout the season in case of questions.

Market Probe uses SPSS (Statistical Package for the Social Sciences) for data entry, cleaning, analysis, and reporting. After collection, the farm data is entered into a local database, reviewed, and quality-checked by the local Market Probe agency. In the case of missing values or inconsistencies, farmers are re-contacted. In some cases, grower data was verified with local experts (e.g. retailers) to ensure data accuracy and validity. After country-level cleaning, the farm-level data is submitted to the global Market Probe headquarters for processing. In the case of missing values or inconsistences, the local Market Probe office was re-contacted to clarify and solve issues.

The results were shared with reference and benchmark respondents in the farm network. Farmers were able to compare their individual performance to the respective cluster average, building an important starting point for future productivity increases.

4.4. Progress measurement

The basis for progress management is the productivity and efficiency percentage increases measured on reference farms. The overall trend will be measured against a 20% improvement target to be achieved by 2020. The baseline year for all clusters is 2014, the starting year of the data collection. The clusters in scope have targets which were baselined in 2014 and that are targeted to be met in 2020. Syngenta measures productivity performance of crop production by relating the crop yield to a set of inputs and resources used in its production. The key performance indicators (KPIs) represent partial measures of agricultural productivity and efficiency:

- Land productivity
- Labor efficiency
- Nitrogen efficiency
- Seed efficiency
- Pesticide application efficiency
- Pesticide efficiency
- Irrigation water efficiency
- Energy efficiency

The selected KPIs "Land Productivity Index", "Nutrient Efficiency Index[6]", and "Pesticide Application Efficiency Index" are published in the Annual Review. For these, the percentage increase will be displayed in a frequency table that groups the number of clusters separately for reference and benchmark farms.

Cluster-level efficiency indicators are published as total values on www.goodgrowthplan.com for each cluster. This excludes cluster-level data for the USA. Results from reference and benchmark farms are aggregated to ensure data privacy of individual growers in clusters with small samples of reference farms.

a. Land productivity index

Name	**Land productivity index**
Unit of measurement	%
Definition	The average percentage change in land productivity measured as

[6] Nutrient here refers to nitrogen.

	marketable crop yield in metric tons per hectare in the reporting year relative to the baseline year.
Calculation	1. Crop output in metric tons per land unit for the respective crop periods is reported by the grower. 2. The output per land unit is converted to output per hectare. 3. The cluster average is calculated for reference farms. 4. The index is calculated as the % difference in the cluster average $$\Delta Y_j^{2015} = \frac{\frac{\sum_{i=1}^{n} y_i^{2015}}{n} - \frac{\sum_{i=1}^{n} y_i^{2014}}{n}}{\frac{\sum_{i=1}^{n} y_i^{2014}}{n}} * 100 = \left(\frac{\sum_{i=1}^{n} y_i^{2015}}{\sum_{i=1}^{n} y_i^{2014}} - 1\right) * 100$$ where ○ ΔY_j^{2015} is percentage change in crop yields ○ y_i^{2015} is crop yield per hectare of farm i in crop period 2015 ○ y_i^{2014} is crop yield per hectare of farm i in crop period 2014 ○ j is cluster ○ $i = 1, \dots, n$ farms 5. The overall aggregated productivity increase for reference farms is calculated as $$\Delta \bar{Y}^{2015} = \frac{\sum_{j=1}^{m} \Delta Y_j^{2015}}{m}$$ where ○ $\Delta \bar{Y}^{2015}$ is percentage change in crop yields ○ $j = 1, \dots, m$ clusters
Limitations	Crop yields might vary significantly from year to year due to environmental and other stress conditions.

b. Nutrient efficiency index

Name	**Nutrient efficiency index**
Unit of measurement	%
Definition	The average percentage change in nutrient efficiency measured as nitrogen input from chemical fertilizer applied in kilograms per metric ton marketable crop yield in the reporting year relative to the baseline year.
KPI calculation	1. Data on nitrogen input in kilogram per land unit from chemical

<table>
<tr><td></td><td>fertilizer applied is reported by the grower.
2. The input per land unit is converted to input per hectare.
3. For each farm, nitrogen input is divided by crop yield per hectare, resulting in nutrient efficiency measured in kilograms of nitrogen input per ton of crop output.
4. The cluster average is calculated for reference farms.
5. The index is calculated as the % difference in the cluster average of inverse input efficiency[7]
$$\Delta Y_j^{2015} = \left(\left(\frac{1}{\frac{\sum_{i=1}^{n} y_i^{2015}}{n}} - \frac{1}{\frac{\sum_{i=1}^{n} y_i^{2014}}{n}}\right) * \frac{\sum_{i=1}^{n} y_i^{2014}}{n}\right) * 100 = \left(\frac{\sum_{i=1}^{n} y_i^{2014}}{\sum_{i=1}^{n} y_i^{2015}} - 1\right) * 100$$
where
○ ΔY_j^{2015} is percentage change in input efficiency
○ y_i^{2015} is input efficiency of farm i in crop period 2015
○ y_i^{2014} is input efficiency of farm i in crop period 2014
○ j is cluster
○ $i = 1, \dots, n$ reference farms</td></tr>
<tr><td>Limitations</td><td>The index does not consider the nitrogen balance in the soil. Hence, any changes over time have to be interpreted carefully. The KPI does not consider nitrogen inputs from organic fertilizer. Data for organic fertilizer input is available, but needs to be calculated to N equivalents using assumptions.</td></tr>
</table>

c. Pesticide Application efficiency index

Name	**Pesticide application efficiency index**
Unit of measurement	%
Definition	The average percentage change in pesticide efficiency measured as the number of pesticide applications per metric ton of marketable crop yield in the reporting year relative to the baseline year.

[7] The inverse of input efficiency is used to obtain a positive change when input efficiency increases. An increase in input efficiency measured as input per output would result in a negative percentage change.

Calculation	1. Each pesticide treatment during the production cycle is recorded and reported by the grower. 2. The number of pesticide applications per land unit is calculated by summing-up the number of treatments. In the case where two or more pesticides were applied as one application, they are counted as one treatment (e.g. tank mix). Seed treatment is calculated as one treatment. 3. The applications per land unit are converted to applications per hectare. 4. To calculate pesticide application efficiency of a farm, the number of pesticide applications is divided by crop yield in tons. 5. The cluster average is calculated for reference farms. 6. The index is calculated as the % difference in the cluster average of inverse input efficiency[8] $$\Delta Y_j^{2015} = \left(\left(\frac{1}{\frac{\sum_{i=1}^{n} y_i^{2015}}{n}} - \frac{1}{\frac{\sum_{i=1}^{n} y_i^{2014}}{n}}\right) * \frac{\sum_{i=1}^{n} y_i^{2014}}{n}\right) * 100 = \left(\frac{\sum_{i=1}^{n} y_i^{2014}}{\sum_{i=1}^{n} y_i^{2015}} - 1\right) * 100$$ where a. ΔY_j^{2015} is percentage change in input efficiency b. y_i^{2015} is input efficiency of farm i in crop period 2015 c. y_i^{2014} is input efficiency of farm i in crop period 2014 d. j is cluster e. $i = 1, \ldots, n$ reference farms
Limitations	Application efficiency depends on the biotic pressure during the season.

d. Pesticide AI efficiency index

Name	**Pesticide AI efficiency index**
Unit of measurement	%
Definition	The average percentage change in pesticide active ingredient (AI) efficiency measured as the amount of pesticide AI input per metric ton of

[8] The inverse of input efficiency is used to obtain a positive change when input efficiency increases. An increase in input efficiency measured as input per output would result in a negative percentage change.

	marketable crop output in the reporting year relative to the baseline. Included are active ingredients of fungicides, herbicides, insecticides, and seed treatment products. Not included are active ingredients of fertilizers, miticides, acaricides, rodenticides, nematicides, molluscicides, plant growth regulator, harvest aids, and adjuvants.
Calculation	1. Each pesticide application, including the brand name(s) of the product and dosage rate in gram or milliliter per land unit applied during the production cycle, is reported by the grower. 2. The input per land unit is converted to input per hectare. 3. The database www.homologa-new.com, label information, or other databases are used to obtain information on the active ingredient concentration of each pesticide product. The quantity of active ingredient input is measured as grams per liter or grams per kilogram product solvent. 4. The amount of active ingredient applied per hectare is calculated by multiplying the dosage rate with the active ingredient concentration. 5. The total amount of pesticide active ingredients applied in kilograms per hectare is calculated by taking the sum of active ingredients of all considered pesticide applications. 6. To calculate pesticide active ingredient efficiency, the total amount of pesticide active ingredients is divided by the crop yield in tons for each farm. 7. The cluster average is calculated for reference farms. 8. The index is calculated as the % difference in the cluster average of inverse input efficiency[9] $$\Delta Y_j^{2015} = \left(\left(\frac{1}{\frac{\sum_{i=1}^{n} y_i^{2015}}{n}} - \frac{1}{\frac{\sum_{i=1}^{n} y_i^{2014}}{n}}\right) * \frac{\sum_{i=1}^{n} y_i^{2014}}{n}\right) * 100 = \left(\frac{\sum_{i=1}^{n} y_i^{2014}}{\sum_{i=1}^{n} y_i^{2015}} - 1\right) * 100$$ where a. ΔY_j^{2015} is percentage change in input efficiency b. y_i^{2015} is input efficiency of farm i in crop period 2015 c. y_i^{2014} is input efficiency of farm i in crop period 2014

[9] The inverse of input efficiency is used to obtain a positive change when input efficiency increases. An increase in input efficiency measured as input per output would result in a negative percentage change.

	d. j is cluster e. $i = 1, \ldots, n$ reference farms
Limitations	Due to differences in the mode-of-action, an increase in pesticide AI efficiency may have limited interpretability.

e. Seed efficiency

Name	Seed efficiency index
Unit of measurement	%
Definition	The average percentage change in seed efficiency measured as kilograms of seeds per metric ton of marketable crop yield in the reporting year relative to the baseline year.
Calculation	1. The amount of seeds used in bags or kilograms per land unit is recorded and reported by the grower. 2. The input per land unit is converted to input per hectare. 3. For each farm, the amount of seeds used is divided by the crop yield, resulting in seed efficiency measured in kilograms of seed input per ton of crop output. 4. The cluster average is calculated for reference farms. 5. The index is calculated as the % difference in the cluster average of inverse input efficiency[10] $$\Delta Y_j^{2015} = \left(\left(\frac{1}{\frac{\sum_{i=1}^{n} y_i^{2015}}{n}} - \frac{1}{\frac{\sum_{i=1}^{n} y_i^{2014}}{n}} \right) * \frac{\sum_{i=1}^{n} y_i^{2014}}{n} \right) * 100 = \left(\frac{\sum_{i=1}^{n} y_i^{2014}}{\sum_{i=1}^{n} y_i^{2015}} - 1 \right) * 100$$ where a. ΔY_j^{2015} is percentage change in input efficiency b. y_i^{2015} is input efficiency of farm i in crop period 2015 c. y_i^{2014} is input efficiency of farm i in crop period 2014 d. j is cluster e. $i = 1, \ldots, n$ reference farms

[10] The inverse of input efficiency is used to obtain a positive change when input efficiency increases. An increase in input efficiency measured as input per output would result in a negative percentage change.

f. Labor efficiency index

Name	Labor efficiency index
Unit of measurement	%
Definition	The average percentage change in labor efficiency measured as manhours per metric ton of marketable crop yield in the reporting year relative to the baseline year.
Calculation	1. The number of hours spent by all workers and the number of workers involved are recorded and reported by the grower for 21 different farming activities. The activities include clearing, ploughing, digging, ridging, ripping, land leveling, greenhouse management, applying fertilizers, mulching, sowing or planting, scouting for pests and diseases, applying pesticides, irrigating, pruning, weeding, harvesting, post-harvest handling, and processing (incl. sorting). 2. The number of hours is multiplied by the number of people involved in each activity, resulting in manhours per activity. Manhours from all activities are summed up and divided by the growing area (field) size. 3. The input per land unit is converted to input per hectare. 4. For each farm, the total number of manhours is divided by the crop yield, resulting in labor efficiency measured in manhours per ton of crop output. 5. The cluster average is calculated for reference farms. 6. The index is calculated as the % difference in the cluster average of inverse input efficiency[11] $$\Delta Y_j^{2015} = \left(\left(\frac{1}{\frac{\sum_{i=1}^{n} y_i^{2015}}{n}} - \frac{1}{\frac{\sum_{i=1}^{n} y_i^{2014}}{n}}\right) * \frac{\sum_{i=1}^{n} y_i^{2014}}{n}\right) * 100 = \left(\frac{\sum_{i=1}^{n} y_i^{2014}}{\sum_{i=1}^{n} y_i^{2015}} - 1\right) * 100$$ where a. ΔY_j^{2015} is percentage change in input efficiency b. y_i^{2015} is input efficiency of farm i in crop period 2015 c. y_i^{2014} is input efficiency of farm i in crop period 2014 d. j is cluster

[11] The inverse of input efficiency is used to obtain a positive change when input efficiency increases. An increase in input efficiency measured as input per output would result in a negative percentage change.

	e. $i = 1, \dots, n$ reference farms
Limitations	Record-keeping of labor inputs for different farm activities is complex and time consuming. It may hence be inconsistent across farms, which can partially be managed through data cleansing. Very large farms were found to outsource many of their labor activities. The indicator has to be interpreted with care.

g. Machine efficiency index

Name	Machine efficiency index
Unit of measurement	%
Definition	The average percentage change in machine efficiency measured as machine hours per metric ton of marketable crop yield in the reporting year relative to the baseline year.
Calculation	1. The type of machine and the total hours it is used are recorded and reported by the grower for 21 different farming activities. The considered farm activities include clearing, ploughing, digging, ridging, ripping, land leveling, greenhouse management, applying fertilizers, mulching, sowing or planting, scouting for pests and diseases, applying pesticides, irrigating, pruning, weeding, harvesting, post-harvest handling, processing (incl. sorting), and other activities. 2. Machine-hours from all activities are summed up and divided by the growing area (field) size in hectare. 3. The input per land unit is converted to input per hectare. 4. For each farm, the total number of machine-hours is divided by crop yield, resulting in labor efficiency measured in machine-hours per ton of crop output. 5. The cluster average is calculated for reference farms. 6. The index is calculated as the % difference in the cluster average of inverse input efficiency[12] $$\Delta Y_j^{2015} = \left(\left(\frac{1}{\frac{\sum_{i=1}^{n} y_i^{2015}}{n}} - \frac{1}{\frac{\sum_{i=1}^{n} y_i^{2014}}{n}}\right) * \frac{\sum_{i=1}^{n} y_i^{2014}}{n}\right) * 100 = \left(\frac{\sum_{i=1}^{n} y_i^{2014}}{\sum_{i=1}^{n} y_i^{2015}} - 1\right) * 100$$

[12] The inverse of input efficiency is used to obtain a positive change when input efficiency increases. An increase in input efficiency measured as input per output would result in a negative percentage change.

	where ○ ΔY_j^{2015} is percentage change in input efficiency ○ y_i^{2015} is input efficiency of farm i in crop period 2015 ○ y_i^{2014} is input efficiency of farm i in crop period 2014 ○ j is cluster ○ $i = 1, \dots, n$ reference farms
Limitations	Record-keeping of machine inputs for different farm activities is complex and time consuming. Machine hours from different activities may be difficult to compare against each other. The indicator has to be interpreted with care.

h. Irrigation water efficiency index

Name	Irrigation water efficiency index
Unit of measurement	%
Definition	The average percentage change in irrigation efficiency measured as liters of irrigation water input per metric ton of marketable crop yield in the reporting year relative to the baseline year.
Calculation	1. If a grower uses irrigation to grow crops, the amount of irrigation water used per land unit is estimated and reported by the grower. 2. The input per land unit is converted to input per hectare. 3. For each farm, the amount of irrigation water used is divided by the crop yield, resulting in irrigation water efficiency measured in liters per ton of crop output. 4. The cluster average is calculated for reference farms. 5. The KPI is calculated as the % difference in the cluster average of inverse input efficiency[13] $$\Delta Y_j^{2015} = \left(\left(\frac{1}{\frac{\sum_{i=1}^{n} y_i^{2015}}{n}} - \frac{1}{\frac{\sum_{i=1}^{n} y_i^{2014}}{n}} \right) * \frac{\sum_{i=1}^{n} y_i^{2014}}{n} \right) * 100 = \left(\frac{\sum_{i=1}^{n} y_i^{2014}}{\sum_{i=1}^{n} y_i^{2015}} - 1 \right) * 100$$ where

[13] The inverse of input efficiency is used to obtain a positive change when input efficiency increases. An increase in input efficiency measured as input per output would result in a negative percentage change.

	○ ΔY_j^{2015} is percentage change in input efficiency ○ y_i^{2015} is input efficiency of farm i in crop period 2015 ○ y_i^{2014} is input efficiency of farm i in crop period 2014 ○ j is cluster ○ $i = 1, \dots, n$ reference farms
Limitations	Tracking systems for use of irrigation water may be different across farms (e.g. water meters or sourcing from a river for free) and amounts used have to be compared with care. Climate conditions penalize farms with little rain that will need to irrigate more.

i. Phosphorus efficiency index

Name	**Phosphorus efficiency index**
Unit of measurement	% (kg/kg P)
Definition	The average percentage change in phosphorus efficiency measured as phosphorus input from chemical fertilizer applied in kilograms per metric ton of marketable crop yield in the reporting year relative to the baseline year.
Calculation	1. Data on phosphorus input in kilograms per land unit from chemical fertilizer applied are reported by grower. 2. The input per land unit is converted to input per hectare. 3. For each farm, phosphorus input is divided by crop yield, resulting in chemical phosphorus efficiency measured in kilograms of phosphorus input per ton of crop output. 4. The cluster average is calculated for reference farms. 5. The index is calculated as the % difference in the cluster average of inverse input efficiency[14] $$\Delta Y_j^{2015} = \left(\left(\frac{1}{\frac{\sum_{i=1}^{n} y_i^{2015}}{n}} - \frac{1}{\frac{\sum_{i=1}^{n} y_i^{2014}}{n}}\right) * \frac{\sum_{i=1}^{n} y_i^{2014}}{n}\right) * 100$$ $$= \left(\frac{\sum_{i=1}^{n} y_i^{2014}}{\sum_{i=1}^{n} y_i^{2015}} - 1\right) * 100$$ where

[14] The inverse of input efficiency is used to obtain a positive change when input efficiency increases. An increase in input efficiency measured as input per output would result in a negative percentage change.

	○ ΔY_j^{2015} is percentage change in input efficiency ○ y_i^{2015} is input efficiency of farm i in crop period 2015 ○ y_i^{2014} is input efficiency of farm i in crop period 2014 ○ j is cluster ○ $i = 1, \dots, n$ reference farms
Limitations	The index does not consider the phosphate balance in the soil. Changes in phosphate efficiency must be interpreted with care. There may be many unobservable factors leading to differences in phosphorus efficiency.

j. Potassium efficiency index

Name	**Potassium efficiency index**
Unit of measurement	%
Definition	The average percentage change in potassium efficiency measured as potassium input from chemical fertilizer applied in kilograms per metric ton of marketable crop yield in the reporting year relative to the baseline year.
Calculation	1. Data on potassium input in kilograms per hectare from chemical fertilizer applied are reported by grower. 2. The input per land unit is converted to input per hectare. 3. For each farm, potassium input is divided by crop yield, resulting in chemical potassium efficiency measured in kilograms of potassium input per ton of crop output. 4. The percentage increase in potassium efficiency (y_i^{2015}) is calculated for each farm individually. 5. The cluster average is calculated for reference farms. 6. The index is calculated as the % difference in the cluster average of inverse input efficiency[15] $$\Delta Y_j^{2015} = \left(\left(\frac{1}{\frac{\sum_{i=1}^{n} y_i^{2015}}{n}} - \frac{1}{\frac{\sum_{i=1}^{n} y_i^{2014}}{n}} \right) * \frac{\sum_{i=1}^{n} y_i^{2014}}{n} \right) * 100 = \left(\frac{\sum_{i=1}^{n} y_i^{2014}}{\sum_{i=1}^{n} y_i^{2015}} - 1 \right) * 100$$

[15] The inverse of input efficiency is used to obtain a positive change when input efficiency increases. An increase in input efficiency measured as input per output would result in a negative percentage change.

	where ○ ΔY_j^{2015} is percentage change in input efficiency ○ y_i^{2015} is input efficiency of farm i in crop period 2015 ○ y_i^{2014} is input efficiency of farm i in crop period 2014 ○ j is cluster ○ $i = 1, \ldots, n$ reference farms
Limitations	The index does not consider the potassium balance in the soil. Changes in potassium efficiency must be interpreted with care. There may be many unobservable factors leading to differences in potassium efficiency.

The selected KPIs "Land Productivity Index", "Nutrient Efficiency Index[16]", and "Pesticide Application Efficiency Index" are published in the Annual Review. For these, the percentage increase will be displayed in a frequency table that groups the number of clusters separately for reference and benchmark farms.

Cluster-level efficiency indicators are published as total values on www.goodgrowthplan.com for each cluster. This excludes cluster-level data for the USA.

When sufficient years of data are available, Market Probe will use statistical tools, such as panel analysis, to derive more precise estimates about the increase in crop productivity and input efficiency.

4.5. Outlook

The next data collection for the reporting period October 2015 – September 2016 starts in March/April 2016.

5. Changes versus previous release

August 3rd 2016:

- KPIs for were updated with available data.

6. Approval of non-financial performance

The Good Growth Plan data is published as a global aggregate in the Non-financial performance summary on pages 57 to 62 of the Annual Review 2015. This summary was approved by the Board of Directors on February 2, 2016. Syngenta's Board of Directors and management are responsible for

[16] Nutrient here refers to nitrogen.

establishing and maintaining adequate internal controls over non-financial reporting. Syngenta's internal controls over non-financial reporting are designed to provide assurance to Syngenta's Board of Directors and management regarding the reliability of non-financial reporting and the preparation and fair presentation of the information published in the Non-financial performance summary. All internal controls, no matter how well designed, have inherent limitations and therefore may not prevent or detect misstatements. In designing internal controls over non-financial reporting, Syngenta used the criteria established in Internal Control – Integrated Framework (2013) issued by the Committee of Sponsoring Organizations of the Treadway Commission (COSO). PricewaterhouseCoopers AG, Switzerland, an independent registered public accounting firm, has issued an opinion on Syngenta's Non-financial performance summary, which is included in the Annual Review 2015 on page 63.

7. Contact information

For questions and inquiries regarding this dataset and documentation, please contact goodgrowthplan.data@syngenta.com.