__Original Research Article__

Evaluation of different Arrowroot (*Maranta arundinacea* L.) accessions for high rhizome yield with good quality and starch content

Abstract

Aim: Arrowroot (*Maranta arundinacea* L) is an underutilized tuber crop belonging to the family marantaceae. This study mainly aims to evaluate different arrowroot accessions for quality starch and best yield.

Study of design: The field experiment was conducted in randomized block design with total ten accessions and three replications.

Place and duration of research: The present investigation was undertaken at the College Orchard, Department of Vegetable Science, Horticultural College & Research Institute, TNAU, Coimbatore during the year 2022.

Methodology: In this study, ten arrowroot accessions *viz.,*TAr18-01, TAr18-02,TAr18-04,TAr18-05,TAr18-10, TAr18-11, TAr18-12, TAr18-13, TAr18-14 and Local were evaluated for their growth, yield and quality parameters.

Results: The statistical results revealed that all the accessions significantly differ from each other. Results obtained as maximum height in the accession TAr18-14(132.01cm),maximum number of leaves in TAr18-10 (109.33),number of tillers in TAr18-14 (8.45) and biggest rhizome weight in TAr18-14(198.81g) respectively. The yield traits like rhizome length (25.49 cm),diameter(9.46cm) and number of rhizome per plant (30.00), rhizome yield per plant (1.49kg) were maximum in TAr18-10.The quality parameters *viz*., dry matter (%) was highest for TAr18-10(56.76%),TSS in TAr18-12 (27.83%), ash contents in TAr18-10 (3.88%). These parameters mainly decide the quality and nutritive value of Arrowroot. There is a significant variation in the quality parameters like starch, TSS, dry matter, protein, crude fiber. Among various accessions TAr18-04 recorded the highest starch (54.62%) and TAr18-14recorded highest protein content(6.194%).Amylose content (21.88%) was maximum in TAr18-01.

Conclusion: It can be concluded from the following study that TAr18-10 recorded highest rhizome yield, dry matter content with quality starch and can be selected for further evaluation and exploitation in industrial applications**.**

Keywords: *Arrowroot, yield, starch, amylose, amylopectin, protein*

1. INTRODUCTION

Arrowroot *(Maranta arundinaceous* L.*)* is an important underutilized tuber vegetable in the marantaceae family. The plants are upright, herbaceous, and grows up to a height of 60-180cm, producing long, white, cylindrical, obovoid rhizomes that are considered edible**.** Globally, it is grown in the West Indies, Southeast Asia, Australia, South and East Africa(1)**.** In India, it is mostly cultivated in North Eastern states,West Bengal, Orissa, Assam and South India especially in Kerala. In Kerala, arrowroot powder is used as health drinks. Being a minor crop, it is mostly planted as an intercrop between coconut, arecanut and rubber plantation in South India. The starch content of arrowroot can vary depending on factors such as the variety of arrowroot, growing conditions, and processing methods(2).Arrowroot is a starchy root vegetable that is widely used in cooking as a thickening agent. Its pomace which is usually the left over obtained from arrowroot after processing can be used for multi-purpose. It does not have direct use in typical culinary or industrial contexts. It may be used as compost as it is completely organic in nature, improves soil structure, and adds nutrients to the soil, animal feed, due to its high fiber content.

Arrowroot is considered to have purest form of starch. On an average, arrowroot typically contains around 23-29%starch(3),(4).Due to its low glycemic index around 14(5),it is easily digestible and also contemplated as the best food for babies. Arrowroot porridge is also used as a substitute for breast milk for weaned off babies. It is a good source of proteins, folates *etc.* It also contains gluten free starch which is life saving for celiac disease patients(6); (7).The worldwide frequency of celiac disease is believed to be between 0.5 and 1.0%, however the Arab population of Western Sahara has a higher incidence of 5.6% (8). Its starch is used as base in cosmetics, ice cream stabilizer, binder and excipient in pharmaceutical tablets and capsules. It helps in holding the ingredients together and provides cohesive properties to the formulation. Starch is sometimes used as a coating agent for tablets, especially in the production of chewable or orally disintegrating tablets. Arrowroot starch can act as an emulsifier in pharmaceutical creams, ointments *etc*. It helps to stabilize the emulsion and prevent the separation of oil and water phases(9).It is known for its soothing and healing properties. It is sometimes used in pharmaceutical topical preparations such as powders, creams, and ointments for its potential benefits in treating skin conditions like rashes, burns, and irritations.

Arrowroot starches offer potential therapeutic benefits, such as the treatment of stomach ulcers and gastrointestinal tract protection(10). Arrowroot starch are easily digestible (11).Arrowroot starches had a low in vitro digestibility rate, which was beneficial for people suffering from obesity and diabetes(12).

Arrowroot has several nutritional uses; yoghurt preparation is one of them. Yoghurt, also spelt 'yogurt', is a dairy product produced by fermenting milk with certain bacterial cultures. Because of its antioxidant, antihypertensive, anti-diabetic, and anti-hypercholesterolemia qualities, yoghurt is often included in many healthy diet programs(13).It has a good amount of folate content in it which may be useful for pregnant and menstruating women. Research on evaluation of arrowroot on rhizome yield, quality and starch aspects is meager, hence the investigation was performed for growth, yield and quality parameters in arrowroot accessions.

2.MATERIALS AND METHODS

2.1 MATERIALS

The present study was conducted to scrutinize the highest yielding accession of arrowroot. The experiment was laid out in college orchard HC&RI, Tamil Nadu Agricultural University, Coimbatore. The experimental plot is located at 11.0122° N, 76.9354°E.The soil type is sandy loam with a pH of 7.6.The total of ten accessions of fresh arrowroot tubers were collected from CTCRI, Thiruvananthapuram and Kanyakumari district. The experiment was conducted in randomized block design with a spacing of 60x45cm. Ten accessions of arrowroot namely, TAr18-01, TAr18-02,TAr18-04,TAr18-05, TAr18-10, TAr18-12, TAr-14 and Local with 3 replications were planted in a plot size of 150 square meters. After planting cultural practices like fertilizer application, earthing up, weeding and plant protection were followed based on CTCRI, Thiruvananthapuram, Package of practices. Arrowroot (14)accessions were evaluated for growth yield, qualityand biochemical parameters for its utilization in food industries.

2.2 METHODS

2.2.1 Plant height

For the accurate measurement of plant height, the field is selected ensuring that all the plants are of similar age. The data were taken at monthly interval. Then a reference point from where we measure the height of the plant is selected. This point is typically the soil surface or the base of the stem.The ruler or measuring tape was carefully, vertically placed next to the plant. Then a zero mark with the reference point we established earlier was marked. Then the height was recordedwhere the top of the plant reaches on the ruler.

2.2.2 Number of leaves

Leaves are the green, usually flat structures that are attached to the stems or branches of the plant. In the case of arrowroot, each leaf emerges from the stem one after the other, and they don't grow directly opposite to each other. Number of leaves were counted at monthly interval and added finally.

2.2.3 Number of tillers

Measuring the number of tillers in a plant is a common practice in agriculture and plant science to assess the overall health and growth of the plant. Tillers are lateral shoots that arise from the base of the main stem, and they can significantly influence the plant's yield and productivity. Tillers generally emerge from axillary buds, often near the soil surface. Once we identify a tiller, each individual tiller present on the plant is counted.

2.2.4 Rhizome number and Rhizome weight

Once the harvesting part is over, rhizomes are carefully removed out of the soil. In crops like arrowroot, the rhizomes are very tightly bonded to the soil and with each other. So, while harvesting, it should be conscientiously removed and separated from the bunch. After cleaning of soil, the total number of rhizomes per plant and total rhizome weight (g) per plant was recorded.

Similarly, the biggest rhizome weight (g) is observed the weighing balance.

Figure 1. Arrowroot rhizome

2.2.4 Rhizome length and breadth

Rhizomes are usually underground, horizontal stems that grow laterally from the main plant. So it should be carefully dug around the plant to expose the rhizome without damaging it. Excess of soil and other dirt particles should be cleaned. Measurement of the length is done using a ruler or measuring tape, it is gently placed along the entire length of the rhizome. Similarly measurement of the breadth is done by using vernier calipers to measure its widest point. For the irregularly shaped rhizomes, multiple points are measured and an average is calculated to get more accurate measurement.

3.Flour preparation from rhizome

Arrowroot rhizomes were washed properly, peeled and sliced into small pieces around 2mm.These were then dried in hot air oven at 105℃ for 2 hours in analytical laboratory HC&RI, Coimbatore. After that weight is taken at regular interval of 30 minutes to obtain a constant weight. The dried slices of rhizome is then grinded completely into a fine powder.

3.1 Starch extraction

With modifications, arrowroot starch was extracted using the approach published by (15). Arrowroot rhizomes were picked, peeled, sanitized with piped water, sliced, and submerged in a potassium metabisulfite solution (0.03%, m/m) for 15 minutes. The arrowroot rhizome was crushed in a high-speed stainless steel industrial blender (Spool, Brazil) with deionized water at a ratio of 1:2 (m/m) of arrowroot to water for 5 minutes, until a homogenous mass was obtained. The resulting bulk was filtered using a double cotton cloth. The mass washing with deionized water was performed three times to ensure fiber separation and full starch removal. Following roughly 12 hours of starch sedimentation, the water was separated by manual flow and starch at the bottom was collected and dried in hot air oven @60℃ for 4 hours.

3.2 Starch estimation

The Anthrone technique developed by(16) was also used to analyze starch. 0.5 g of complete sugar removal pellet was collected and 5 ml of cooled distilled water was added, followed by 6.5 ml of 52%

perchloric acid. After centrifuging the solution at 5000 rpm for 20 minutes, the supernatant was collected in a conical flask. Distilled water was used to make up to 100 mL of supernatant.0.5 mL of that solution in a test tube and4.0 mL of pre-chilled anthrone was added, we heat the test tubes in a boiling water bath for 8 minutes until a green or dark green colour develops, then the test tubes are cooled and OD values are measured at 630nm against the blank.

3.2.1 pH estimation

The arrowroot flour of total ten accessions was taken. A 10% (w/v) sample suspension in distilled water was prepared. In a warring micro blender, the suspension was completely blended. It was allowed to stand for 30 minutes with constant stirring and the reading was measured using pH meter.

3.2.2 TSS Estimation

The total soluble solids (TSS) (°Brix) of the flour sample were calculated using a hand refractometer and a 10% aqueous solution of each flour, as described by (17). TSS is often expressed in terms of percentage or degrees Brix (°Bx).

3.2.3 Moisture content

Moisture content was determined by the method suggested by(18).Samples were dried in the oven at 105℃ for 2 hours ,until a constant weight was observed. The samples were then cooled using a desiccator and the dry weight of the samples were noted using a weighing balance.

$$Moisture\ content = \frac{w1-w2}{w1} \times 100$$

Where ,

W_1 is the initial weight of the sample before drying; W_2 is the final weight of the sample after drying.

3.2.4 Ash content

The ash content was assessed using the AOAC technique. One gram of the sample from each accession was weighed into a previously weighed dish. It was then put in a Muffle furnace (CARBOLITE) at 550℃ for 12 hours to get ash. The dish was cooled using a desiccator and weighed. The total ash was computed as a percentage of the original sample weight.

$$Percentage\ of\ Ash = \frac{w3-w2}{w2-w1} \times 100$$

Where,

W1=Weight of empty dish

W2=Weight of empty dish + sample before drying

W3=Weight of empty dish + ash after ashing

3.2.5 Dry matter content

It refers to the weight of the solid material remaining in a crop after all the water and moisture have been removed. It represents the plant material's solid content and is an important parameter in agriculture and food science. Dry matter content is typically expressed as a percentage of the total weight of the fresh crop.

$$Dry\ matter\ (\%) = \frac{dry\ weight\ of\ sample}{fresh\ weight\ of\ sample} \times 100$$

3.2.6 Protein estimation

The protein content was determined using the Lowry's method(19). Approximately 0.5g of arrowroot flour samples were grinded well in pestle and mortar using sodium phosphate buffer. The mixture was centrifuged and the supernatant was collected. 1.0 ml of supernatant was transferred to test tube and added with 5.0 ml of Lowry's reagent, allowed to stand for 10 minutes, and then 0.5 ml of Folin-Ciocalteu reagent was added. The solution was mixed well and incubated for 30 minutes in dark condition at room temperature. After that, blue colour was developed which was read at 660nm in a UV spectrophotometer.

3.2.7 Amylose and Amylopectin content determination

The amylose content was assessed using a colorimetric approach based on light transmission via a colored complex formed by amylose when it reacts with iodine, as described by (20)modifications(21). The amylopectin content was calculated using the formula below and is reported as a percentage.

Amylopectin (%) = Starch content – Amylose content

4. Statistical Analysis

The statistical analysis was done using GRAPES (General R-shiny based Analysis Platform Empowered by Statistics) software version 1.0.0.developed by Department of Agricultural Statistics, College of Agriculture, Vellayani, Kerala Agricultural University.

5. Results and Discussions

The current study found that there were substantial differences in growth, yield, and quality indices across the different accessions. In the present research, significant variation was noticed in the length of rhizome, rhizome girth, biggest rhizome weight, single rhizome weight, number of rhizome per plant, rhizome yield per plot and rhizome yield per hectare.

5.1 Agronomic traits

The research conducted under arrowroot showed there is a wide range of differences in agronomic traits. The plant height was measured at the harvestable stage and the average was enumerated (Table 1). The analysis of data showed that there was a significant difference in the plant height among all the accessions taken for the study. The plant height varied from 75.134 cm to 140.24 cm with accession number TAr18-14 being maximum (132.01 cm) followed by TAr18-10 (116.92 cm) and the lowest height was observed in TAr18-02 *ie*. 76.52 cm. Genetic system and some agro-climatic variables have a strong influence on agronomic and morphological aspects such as growth performance (22). Number of tillers per plant ranged between 4.79 to 8.45 with maximum number of tillers in TAr18-14 (8.45) followed by TAr18-11 (7.75) with a mean value of 5.97. The minimum number of tiller was recorded in TAr18-01 (4.79).

Number of leaves per plant ranged from 54.00 to120.00 with highest number of leaves in TAr18-10 (109.33) followed by TAr18-12 (103.00) and the mean value was recorded as 81.63 which gave similar results as cited by (23).

5.2 Yield Traits

Yield is a very complex trait which is influenced by number of factors including climate, soil, temperature, farming practices *etc.* In arrowroot, important factors which impact yield parameters are number of rhizome per plant, rhizome yield per plant, biggest rhizome weight (Table.1).Rhizome is an economic part in arrowroot, among the accessions evaluated, TAr18-10 recorded the highest rhizome length (25.49cm) and diameter (9.46cm) followed by TAr18-14 with a length 23.9cm and diameter of 7.28cm. Rhizome length ranged between10.54cm to 25.49cmwith a mean of 20.61 cm and diameter length ranged between 7.41cm to 9.46 cm with a mean value of 7.30cm. It showed slightly larger value than the one examined by (23).The number of rhizomes per plant varied between 13.33.00 to 30.00.00 with a mean of 21.07.TAr18-10 recorded highest number of rhizome per plant (30.60) followed by TAr18-14 (27.00).The single rhizome weight ranged between 45.54 g to 200.22 g.TAr18-14 (117.16g) recorded highest rhizome weight followed by Local (112.18g). Biggest rhizome weight was found in the range of 52.55g-233.10g.It was observed to be highest in TAr18-14 (198.81g) followed by TAr18-04 (176.96g) with a mean value of 129.68g.

3.1.3. Rhizome yield per plant

The total yield of rhizomes per plot determines the overall production of rhizome per hectare which often plays an important role in evaluating the economics of the crop. In this study, highest rhizome yield was recorded in TAr18-10(1.49kg) followed byTAr18-11 (1.23kg) with a mean value of 9.48kg.

3.2. Quality Traits

The quality parameters viz., starch(%), protein (%), pH, TSS, moisture (%), dry matter(%),crude fiber, ash (%),amylose and amylopectin (%) *etc*, mainly decide the quality and nutritive value of arrowroot. In this study, significant variation in the quality parameters were observed (Table 2.)

The starch content ranged between 31.80-54.63%. The highest starch content was observed in the accession TAr18-04 (54.62%) followed by Local accession (38.01%). The mean value was observed around 36.49%.The results observed in this study was corroborating with the one observed by (24)around 51.97±4.33%.The protein content was estimated to be highest in TAr18-14 (6.19%) followed by Local (5.84%) and lowest in TAr18-12 (4.91%) which was similar as cited by(24).The large proportion of amylose is critical in its selection as a film-forming ingredient because it interferes directly with its final features. So, the technological properties of amylose films are generally superior to those of amylopectin, particularly in terms of mechanical strength and barrier properties. The amylose content was found to be in the range of 14.37% to 22.32%.TAr18-01 recorded maximum amylose content (21.88%)followed by TAr18-12 (21.65%)which was similar as cited by (25) and (26). Amylopectin was observed in the range 13.4%-33.1% with highest percentage in TAr18-04 (33.06%) followed by Local (22.1%) which had high resemblance with the findings of (27).

The pH value of arrowroot accessions ranged between 5.1 to 5.8 making it acidic which was similar to the results obtained by (28). TAr18-02 and TAr18-10 observed a pH of 5.77. The TSS content was found to be highest in TAr18-12 (28.54ºBrix) followed by TAr18-14 (28.5 ºBrix).The minimal percentage of ashes and proteins demonstrates the extracted starch's high quality and purity. The amount of proteins and mineral salts contained in starch must be determined because these compounds are regarded contaminants in the product and can interfere with its physicochemical and technical properties (29).

The moisture content of freshly harvested rhizome was detected to be highest in TAr18-14 (53.64%) followed by TAr18-13 (53.58%) which was similar to the observations made by (30).Similarly, the dry matter percentage was found in the range 45%-70%. Dry matter in a rhizome refers to the weight of the rhizome's tissue remaining after all moisture has been removed. The maximum dry matter percentage was found in TAr18-10 (69.01%) followed by Local (56.76%). These observations were similar to the one recorded by (31).In this study, crude fiber was observed in the range between 2.1-3.9% with a mean value of 3.16%.TAr18-12 recorded highest crude fiber (3.92%) followed by TAr18-04 (3.75%). These results corroborated with the one cited by (32). The ash content was recorded to be highest in TAr18-10 (3.88%) followed by TAr18-01 (3.5%) with a mean value of 3.15%.

4. Correlation of yield and quality traits

It can be observed from (Fig .1) that a positive correlation exists between rhizome yield number of leaves, number of rhizomes per plant rhizome length and diameter while negatively weak correlation was recorded between rhizome yield and plant height. There was a moderately positive correlation observed between rhizome length, diameter and yield/plant. These results were corroborated with the one found by (33). A strong positive correlation was observed between rhizome length and diameter.

5. Conclusion

The current study discovered significant differences in morphological, agronomic, yield, and quality indices among arrowroot accessions. According to current research and studies, the accessions under examination may be clearly distinguished from one another due to their distinct characteristics. With respect to quality parameters accession TAr-18-10 performed best in Coimbatore, recording the maximum yield whereas TAr18-04 recorded maximum percentage of starch content. Furthermore, as an underutilized crop, arrowroot has a lot of potential in the future.

Table1. Mean performance of different arrowroot accessions for agronomic and yield traits

Parameters	Accessions (Mean ± S.D)										CV %
	TAr18-01	TAr18-02	TAr18-04	TAr18-05	TAr18-10	TAr18-11	TAr18-12	TAr18-13	TAr18-14	Local	
Plant height (cm)	76.81±0.92^{e}	76.52±0.31^{e}	105.73±12.42^{bc}	98.99±1.72^{bcd}	116.92±14.56^{ab}	90.10±0.11^{cde}	104.16±7.79^{bc}	81.48±0.43^{de}	132.01±5.86^{a}	114.73±5.27^{ab}	13.5
Number of tillers	4.79±0.59^{e}	5.41±1.05^{de}	6.96±0.56^{bc}	5.06±0.77^{e}	5.720±1.5^{de}	5.88±0.9^{cde}	7.75±1.06^{ab}	5.92±0.60^{cde}	8.45±1.16^{a}	6.28±0.67^{cd}	14.2
Number of leaves	83.66±1.5^{b}	83.66±2.51^{bc}	64.33±6.42^{de}	70.66±3.05^{cd}	109.33±10.06^{a}	100±2.00^{a}	103±2.64^{a}	55±1.00^{e}	74±1.5^{bcd}	70±1.32^{d}	9.6
No. of rhizomes/ plant	13.662.08^{e}	13.33±1.52^{e}	14.00±2.64^{de}	18.33±1.52^{cd}	30.00±4.00^{a}	24.66±1.15^{b}	22.66±1.52^{bc}	19.33±1.52^{c}	27.00±4.0^{ab}	18.66±3.05^{c}	12.6
Rhizome length (cm)	18.456±1.15^{bc}	15.36±3.59^{cd}	18.45±0.84^{bc}	16.01±3.20^{cd}	25.49±4.22^{a}	12.52±2.04^{d}	22.68±1.67^{ab}	22.42±0.97^{ab}	23.99±2.63^{a}	16.12±1.51^{cd}	13.5
Rhizome diameter (cm)	7.75±0.50^{b}	7.82±0.29^{b}	4.59±0.49^{de}	4.66±0.40^{de}	9.46±1.8^{a}	4.16±1.75^{e}	6.546±0.518^{bc}	5.927±0.424^{cd}	7.28±0.10^{bc}	6.307±0.764^{bc}	14.2
Yield/ plant (g)	1142.10±93.2^{ab}	1156.71±102.9^{ab}	910.150±34.5^{bc}	821.931±47.1^{bc}	1491.58±630.1^{a}	823.437±20.8^{bc}	875.88±113.6^{bc}	1223.33±22.1^{c}	702.04±34.1^{c}	931.57±258.^{bc}	22.1
Biggest rhizome weight (g)	62.30±1.99^{f}	52.55±1.50^{f}	176.96±7.39^{ab}	113. ±0.9^{e}	142.71±28.31^{cde}	160.92±3.10b^{c}	124.06±24.58^{de}	117.26±2.20de	198.81±47.01^{a}	147.99±9.13^{bcd}	15.1
Single rhizome weight(g)	46.18±2.18^{e}	61.01±4.14^{de}	150.81±15.64^{a}	45.54±3.13^{e}	91.06±13.61^{c}	75.47±10.19c^{d}	83.05±11.493^{c}	86.99±0.976c	117.16±3.24^{b}	112.18±9.8^{b}	11.1

Table 2. Mean performance of different arrowroot accessions for quality trait

Parameter	Accessions (Mean ± S.D)										CV %
	TAr18-01	TAr18-02	TAr18-04	TAr18-05	TAr18-10	TAr18-11	TAr18-12	TAr18-13	TAr18-14	Local	
Moisture (%)	50.06 ± 0.06^{cd}	47.29 ± 2.70^{ef}	52.52 ± 0.35^{ab}	50.99 ± 0.87^{bcd}	43.23 ± 0.41^{g}	51.44 ± 0.60^{bc}	49.13 ± 0.81^{de}	53.58 ± 1.27^{a}	53.64 ± 1.26^{a}	47.03 ± 1.20^{f}	2.44
Ash(%)	3.52 ± 0.04^{b}	3.16 ± 0.06^{c}	3.46 ± 0.13^{b}	3.45 ± 0.27^{b}	3.88 ± 0.14^{a}	2.52 ± 0.13^{d}	2.267 ± 0.054^{e}	$2.31\pm0.21d^{e}$	3.42 ± 0.01^{b}	3.5 ± 0.12^{b}	4.62
Dry matter (%)	49.93 ± 0.06^{cde}	52.70 ± 2.70^{bc}	47.700 ± 0.7^{de}	49.00 ± 0.87^{de}	56.76 ± 0.41^{a}	49.39 ± 2.06^{cd}	50.25 ± 0.36^{cde}	46.41 ± 1.27^{e}	46.54 ± 1.06^{e}	55.67 ± 4.77^{ab}	4.00
Protein(%)	5.27 ± 0.08^{ef}	5.35 ± 0.25^{ef}	5.54 ± 0.04^{cde}	5.19 ± 0.13^{fg}	$5.74\pm0.27b^{cd}$	5.81 ± 0.15^{bc}	4.91 ± 0.02^{g}	5.49 ± 0.3^{de}	6.19 ± 0.03^{a}	5.84 ± 0.03^{b}	3.10
Starch(%)	35.83 ± 0.71^{c}	32.59 ± 0.41^{e}	54.62 ± 1.65^{a}	33.05 ± 0.27^{e}	35.87 ± 1.26^{c}	33.43 ± 0.84^{de}	35.13 ± 0.50^{c}	31.80 ± 1.38^{e}	35.05 ± 0.052^{cd}	38.01 ± 0.96^{b}	2.61
Crude fiber (%)	$49.93\pm0.06^{\mathbf{a}}$	52.70 ± 2.71^{ab}	47.70 ± 0.7^{bc}	49.00 ± 0.87^{cd}	56.76 ± 0.411^{cde}	49.39 ± 2.060^{cde}	50.25 ± 0.366^{de}	46.41 ± 1.27^{de}	46.54 ± 1.06^{e}	55.67 ± 4.77^{e}	4.0
Amylose (%)	21.88±0.44	14.30±0.07	21.55±0.017	21.05±0.05	18.32±0.10	18.48±0.00	21.65±0.01	16.61±0.28	18.35±0.06	15.81±0.58	1.40
Amylopectin (%)	13.72 ± 0.4^{efg}	18.28 ± 0.47^{c}	33.06 ± 1.66^{a}	11.99 ± 0.21^{g}	17.54 ± 1.28^{c}	14.95 ± 0.84^{ef}	13.48 ± 0.51^{fg}	15.18 ± 1.65^{de}	16.703 ± 0.09^{cd}	22.19 ± 0.75^{b}	5.47
pH	5.35 ± 0.07^{bcde}	5.77 ± 0.06^{a}	$5.60\pm0.20a_{b}$	5.30 ± 0.20^{cde}	5.77 ± 0.0^{6ad}	5.23 ± 0.15^{de}	5.55 ± 0.21^{abc}	$5.46\pm0.30b^{cd}$	5.18 ± 0.03^{e}	5.35 ± 0.09^{bcde}	3.05
TSS (%)	21.28 ± 1.49^{bc}	19.70 ± 1.07^{cd}	20.74 ± 0.43^{bcd}	22.01 ± 0.82^{b}	18.78 ± 0.54^{d}	22.46 ± 1.09^{b}	27.83 ± 1.10^{a}	19.26 ± 1.20^{cd}	26.28 ± 2.21^{a}	27.53 ± 0.66^{b}	5.09

Table 3 Ranking of accessions for Yield and Quality traits

Rank	Yield	Dry matter(%)	Starch (%)	Protein (%)	Amylose (%)	Amylopectin	Crude fibre
I.	TAr18-10	TAr18-10	TAr18-04	TAr18-14	TAr18-01	TAr18-04	TAr18-10
II.	TAr18-13	Local	Local	Local	TAr18-12	Local	Local
III.	TAr18-02	TAr18-02	TAr18-10	TAr18-11	TAr18-04	TAr18-02	TAr18-02

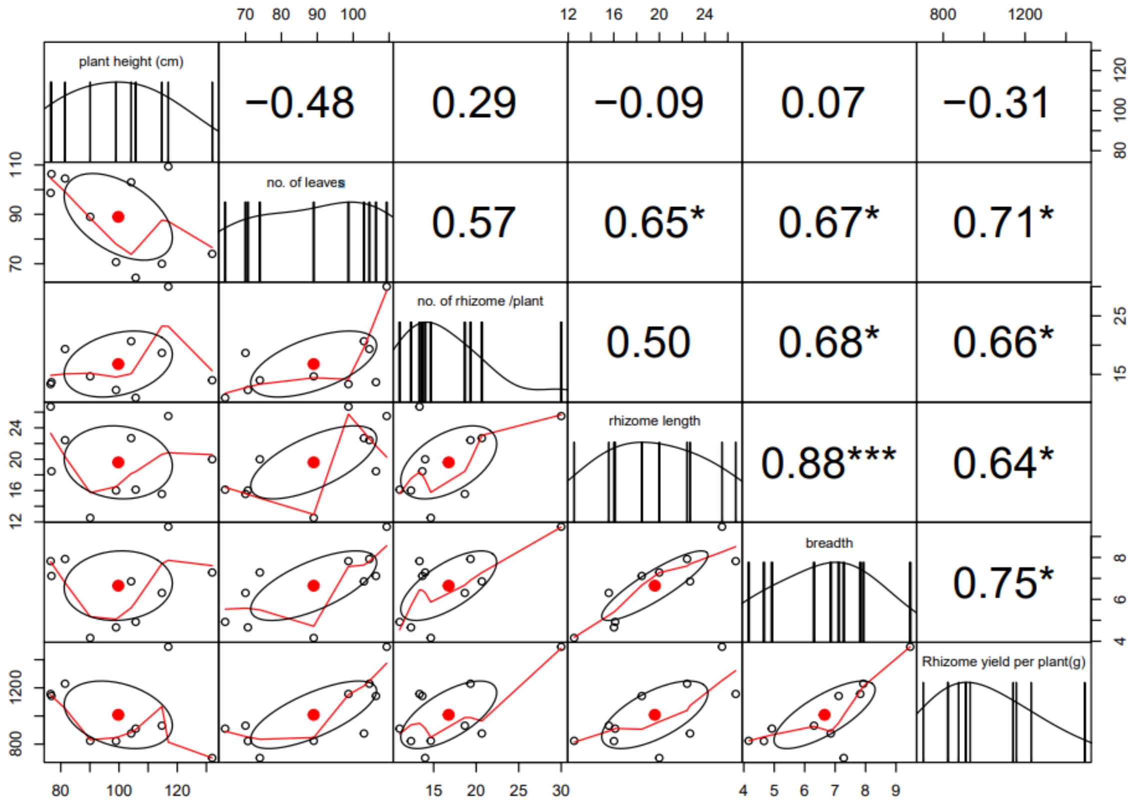

Fig. 2 Correlation between agronomic and yield traits

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