Amaranth as a crop in a changing climate

Summary

Background

- With increasingly unpredictable weather, it is important that we diversify the range of foods grown in our gardens.
- Amaranth is an alternative crop grown worldwide for both its grains and leaves. In the UK, we are familiar with seeing it as the ornamental 'Love lies bleeding' but many multicultural communities on allotments in the UK grow similar varieties to this and harvest them for the leaves.
- This trial compared 3 home saved heritage varieties of amaranth. 72 people grew the crop in locations around the UK ranging from Cornwall to Perthshire and monitored the growth of the plants, took harvests and did a taste test.

Aim

- The aim was to compare the 3 varieties in a range of locations and evaluate whether amaranth was a practical leafy crop for people to grow.

Findings

- Amaranth was productive as a leafy crop, producing on average, just under a kilo of leaves per square metre plot over a 2 – 3 month harvesting period. Some people produced a lot more than this.
- Growers as far north as Perthshire were able to produce reasonable yields. Although amaranth is traditionally grown in hotter climates, it produces yields very quickly so can be grown in locations that only have a very short growing season.
- Amaranth was virtually free of pests and diseases. Nothing affected the crop during the summer when it was growing, whilst other leafy crops were suffering from a range of pests including caterpillars, aphids, flea beetle and leaf miner.
- The vast majority of people (90%) found the taste very pleasant, pleasant or acceptable, with around a third stating that it had a slightly 'grassy' taste.
- Just over half of the participants would consider growing it again. The lack of pests and diseases and productivity were common positive attributes mentioned.
- When it came to choice of varieties, it was interesting that although there was a clear preference for Mrs McGhie, a significant minority also chose the other varieties. This highlights the importance of maintaining a diverse collection to suit different locations, environments and cultural preferences. This is in line with the advice of the IPCC report on food security that stresses the importance of maintaining a diverse collection of seed varieties in order to tackle the future challenges of climate change

Introduction

One of the most difficult aspects of climate change is the unpredictable levels of variability and extremes. In 2022, there were periods in June and July of extremely low rainfall, and consequently crops which have been traditionally considered dependable, such as runner beans, performed very poorly (Garden Organic 2022). Whilst we are not advocating replacing all our crops with alternatives, it pays to look at increasing our crop diversity to spread the risk. Amaranth is just one example of a crop that could be tried. It has many promising properties including drought tolerance and favourable nutritional properties and many consider it an underutilised crop that could be used to address food security in a changing climate (Aderibigbe et al. 2022, Alemayehu, Bendevis, and Jacobsen 2015, Das 2016). Our experience of growing it, is that it remains productive in hot weather and suffers from very few of the pests such as aphids, caterpillars and flea beetle that can plague traditional UK leafy crops in hot summers.

Amaranth is cultivated in many countries around the world. It is grown both for its leaves which are eaten in a similar manner to spinach and its seeds which are eaten as a grain (Ebert, Wu, and Wang n.d., Rastogi and Shukla 2013). It is thought to originate in South America when it was used by the Aztecs 5000 – 7000 years ago (Stallknecht and Schulz-Schaeffer 1993). There is a lack of agreement over the classification of amaranth with some authors stating that there are 70 species ((Das 2016, Thapa and Blair 2018) whilst others claiming that there are as many as 400 ((Ahmad Mir, Mansoor Shafi, and Zargar 2023, Rastogi and Shukla 2013). Amaranth readily forms hybrids between species, which may contribute to the difficulty of defining what is a species (Das 2016).

The spinach-like leaves of amaranth are a good source of iron, zinc and calcium and also contain reasonable levels of the essential amino acids lysine and methionine (Sarker and Oba 2019, Prakash and Pal 1991).The seeds of amaranth are either white, red or black. They have higher levels of proteins and a much better balance of essential amino acids than many other grain crops such as rice (Venskutonis and Kraujalis 2013, Písaříková, Kráčmar, and Herzig 2005).

In the UK, it is not commonly grown as a food crop but is used as an ornamental called 'Love lies bleeding' and is also sometimes found as a weed. It is, however grown by some minority ethnic groups as a leafy crop on a small scale where it can be found grown on allotments and in gardens by cultures including Gujaratis, Jamaicans and Bangladeshis. It has many different names including chauli (Gujarat), callaloo (Jamaica), data and dugi (Bangladesh). Different cultures favour different properties. Jamaicans favour greener varieties with large leaves. Bangladeshis like those with red and green multicoloured leaves and may also favour those with fat stems for putting in soups and stews.

Garden Organic collected home-saved seeds of many different varieties from cities in the UK including Coventry, Birmingham, Leicester, Nottingham and London. Many had been brought over to the UK decades ago, and have now adapted very well to our climate, as growers saved seed from the best performing varieties each year. The home-saved varieties consistently outperformed any varieties that we could obtain commercially (Kell et al. 2018).

In this experiment, we tested 3 varieties:
Mrs McGhie brought over this variety in the 1950s and it has been grown and saved in the Handsworth and Stechford districts of Birmingham ever since. It is a pale green variety originally from Jamaica.
Bangladashi Data was grown and home saved by Islam on an allotment in Perry Barr in Birmingham. It is a vibrant multicoloured variety that is often favoured by the Bengali community.
Mr Jefwa is a dark green variety with the flowers forming deep red plumes. It was collected by Mr Jefwa who is a Gujarati from Uganda. It was originally collected from New Zealand in 1990 but it has been grown and home-saved ever since.

Mrs MGhie

Bangladeshi Data

Mr Jefwa

Figure 1 Amaranth varieties

Aim

The aims of this experiment was to compare the 3 varieties as a leafy crop in a wide range of locations around the country and evaluate whether people find it practical to grow and enjoyable to eat.

Methods

Bed preparation

- Three 1 x 1 m plots were prepared by adding compost, raking to a fine tilth, and removing any large stones in early May

Seed sowing

Participants chose to either sow in module trays or sow directly

Sowing into module trays:

- Participants sowed into module trays with cells approximately 2.5 x 2.5 cm in Mid-May.
- When plants had developed at least 3 true leaves, they were planted out at 20 cm spacing (ie 5 plants per row) in 3 rows to give a total of 15 plants for each variety.

Sowing directly

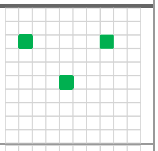
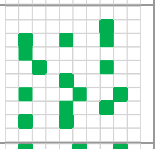
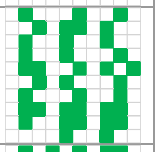
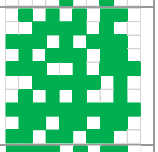
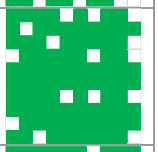
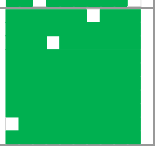
- Participants sowed seeds into 3 rows in late May, then plants were thinned to 20 cm spacing when they had reached the 3 leaf stage.

Measurements and observations

Ground cover

In previous experiments, participants have struggled to estimate ground cover, so we used a 6 point Likert scale with a visual key to facilitate taking measurements. At the beginning of each month, the ground cover of each variety was estimated on a scale of 1 – 6 using the key provided below.

Table 1 Key for assessing ground cover

Score	Range	Description and visualisation	
1	0 – 5%	One or 2 plants present, very little there	
2	5 – 25%	Covering less than a quarter of the ground, not that much there	
3	25 – 50%	Covering up to half of the ground	
4	50 – 75%	Covering more than half of the ground but still some gaps	
5	75 – 95%	Covering most of the ground, only a few small gaps	
6	95 – 100%	Almost complete cover, gaps are very small	

Flowering

The date was recorded when flowering buds started to appear.

Harvesting

Harvests were taken once the plant had reached a height of 30 cm. Initially, the lower third of larger leaves was harvested. Once plants attained a height of 50 cm, harvests were taken by cutting off the stems just above the second or third side shoot. Participants were asked to estimate how many salad bag portions (200g) they harvested from each plot. They were also asked to rank the varieties in order of yield.

Taste test

At the end of August, leaves were harvested and steamed for 5 minutes. The varieties were rated for pleasantness and taste characteristics such as 'bland', 'salty', 'earthy', 'grassy' and 'bitter', and also ranked in order of preference.

Characterisation (optional)

This was an optional activity to examine the variability of the characterisation. The results of this will be presented in a separate document.

Statistical analysis

- Statistical analysis was carried out using Blue Sky Statistics, a graphical interface for using the statistical programming language, R.
- For scalable quantities (eg yield, flowering dates etc), results were analysed using unreplicated one-way Analysis of Variance with each participant site treated as a block to examine any significant differences between the varieties.
- For properties that were sorted into distinct categories (eg flavour, ranking), Pearson's chi squared test was used to examine whether the variety had a significant effect on the distribution between the categories.
- P values where expressed, represent the probability of those differences occurring by random chance, so where the value that is less than 0.05, the effect of the treatment is considered significant.
- Where appropriate, a post hoc comparison was made between individual treatments using a Sidak test. Compact letters (eg a, b and c) were assigned to treatments, with different letters given to treatments that were significantly different (at a probability of $p<0.05$).

Results

Response

Of the 229 people that signed up, 72 people returned results, giving a 31% response rate.

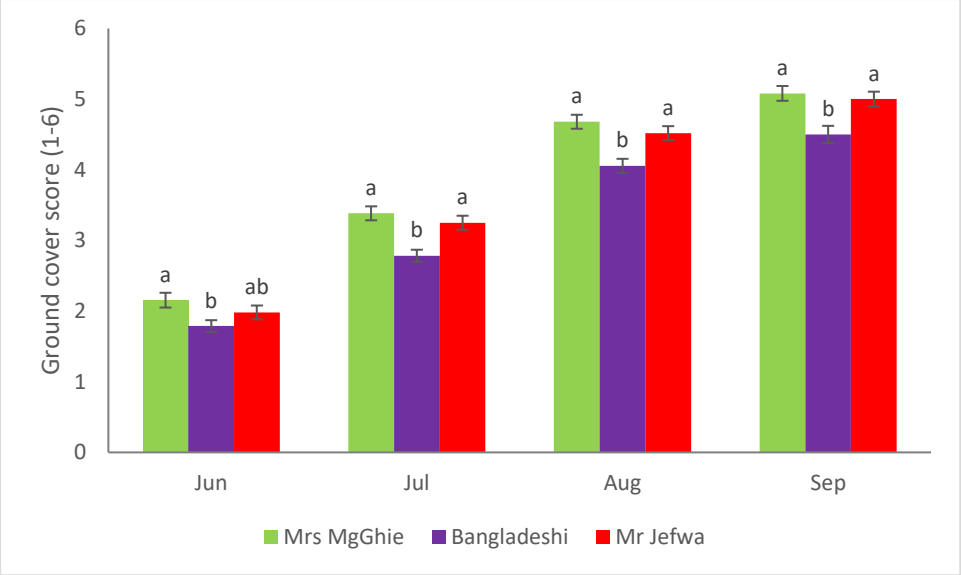
Weather

The 2023 summer was generally wet and dull. June was the warmest month, breaking several temperature records, but July was very cool, dull and wet, experiencing more than twice the average rainfall in some areas. August was a slight improvement, but still lacked sunshine. This resulted in slow establishment and growth which impacted yields of leaves unfavourably in many crops.

Growth of plants

Ground cover

Amaranth can grow rapidly producing a lot of leafy matter under sunny conditions. This was a challenge in 2023: the low levels of sunshine in July may have resulted in slower than normal growth, but despite this, the majority of crops were covering most of the ground by August (Figure 2). Crops at some sites grew much more rapidly, attaining full ground cover by July. Our experience at Ryton was that amaranth grew rapidly throughout June and July, attaining full ground cover in August. Mrs McGhie and Mr Jefwa were more vigorous than Bangladeshi and had significantly ($p<0.001$) larger ground cover on all sample occasions.



Score: 1 = 0 – 5%, 2 = 5 – 25%, 3 = 25 – 50%, 4 = 50 – 75%, 5 = 75 – 95%, 6 = 95 – 100%
Error bars represent standard error of the mean.
Results with different letters are considered significantly different

Figure 2 Ground cover of amaranth varieties

Flowering

As most people who grow amaranth as a food crop in the UK are harvesting the leaves, varieties that flower late have an advantage, as they will sustain leaf production over a longer period. One the crop flowers, leaf production slows, and often the flavour, size and quality of the leaves declines. There were highly significant differences in the dates of flowering between the varieties ($p<0.0001$). Mr Jefwa was the first to flower, so produced leaves over the shortest period. For this variety, the average date of flowering was 26 of July, and crops at a quarter of the sites had started flowering by 14 July. Mrs McGhie had the advantage of flowering last, 7 days later, with an average date of flowering of 2 August, so remained productive the longest.

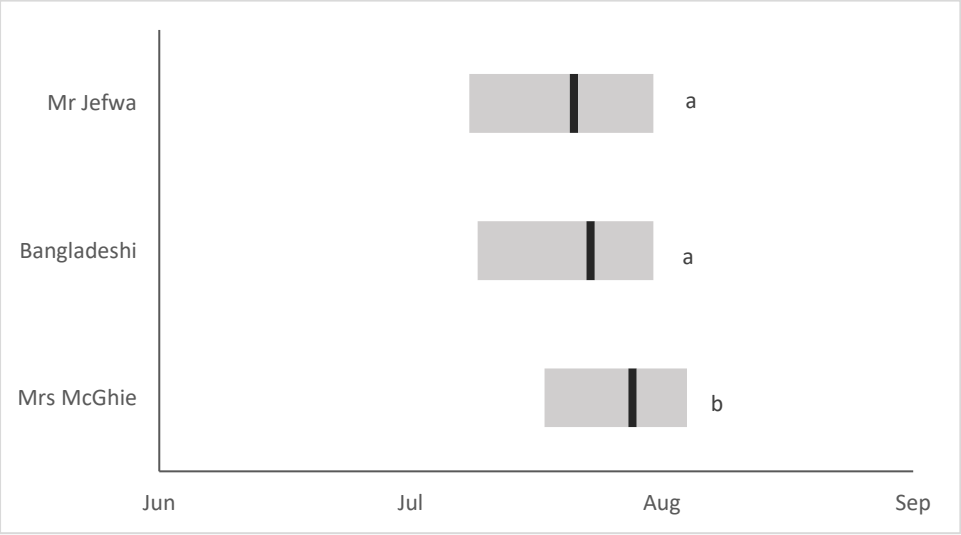


Figure 3 First flowering date of amaranth varieties.

Dark bar shows mean date of flowering, grey box shows 25 – 75% interquartile range of first flowering dates.
Results with different letters are considered significantly different

Figure 4 Mr Jefwa Flowering

We also asked people to rank the order of flowering of the varieties (1-3). Mrs McGhie was ranked as flowering latest at 60% of the growing sites.

Yields

Participants were asked to estimate how many 200g salad bag equivalents, they harvested from the plots. Mrs McGhie was significantly more productive than the other varieties ($p=0.0002$), producing over 5 bags of leaves (ie over 1 kg) on average. Bangladeshi data was the least productive, producing less than 4 bags of leaves over the season.
There was a large variation in the yields achieved between sites. One grower in Lincolnshire managed to achieve 7.6 kg! Despite being a crop that thrives under warm conditions, a grower in Perthshire managed to harvest 1.6 kg from Mrs McGhie, grown outside. At Ryton, we found it to be very productive, harvesting over a kilo of leafy material from a single cut in July, which then regrew to almost its original height in 10 days.

Table 2 Yields from each variety (kg/m^2)

	Mean	SE
Mrs McGhie	1.12^a	0.192
Bangladeshi	0.78^b	0.171
MrJefwa	0.92^b	0.195

Results with different letters are considered significantly different

Separating the yields into 5 categories in order of rank and plotting them on a map didn't show any trends with location within the UK. Growers in Edinburgh and Newcastle were achieving similar yields to growers in Cornwall. This suggests that other factors such as soil conditions and general crop husbandry were more important for determining the yields.

Taste tests

In the taste tests, people rated the taste on a 5 point scale ranging from 'very unpleasant' to 'very pleasant'. Overall, there were no significant differences between the varieties, so the average values are presented here. The majority of responses rated amaranth as neutral (39%) or pleasant (38%).

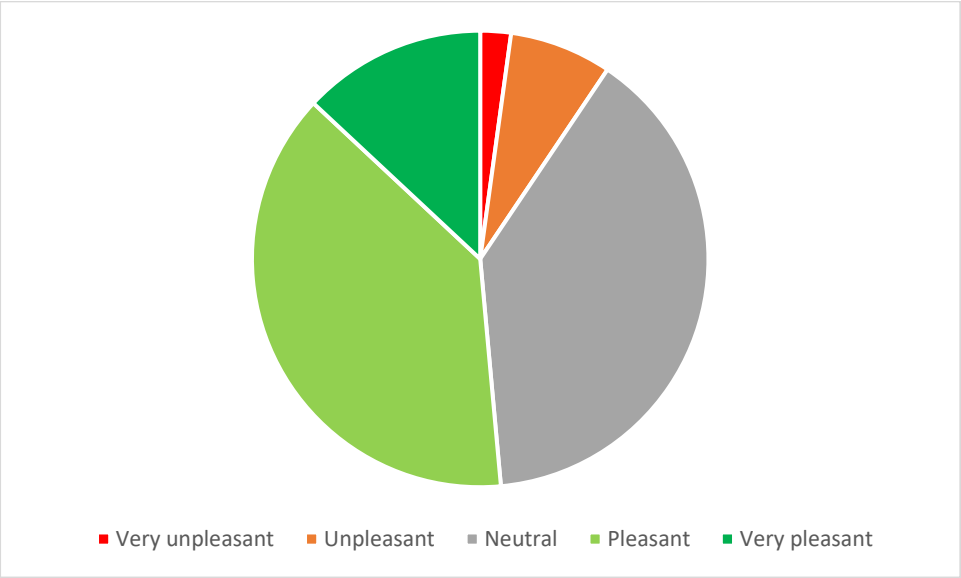


Figure 5 Flavour rating of amaranth amongst participants

We asked people to tick whether they thought the varieties tasted bland, bitter, salty, earthy or grassy. Grassy was the most common characteristic given to the varieties with 37% attributing this flavour to the crop. Bland (17%), bitter (18%) and earthy (19%) were other flavours attributed by a minority of participants. Some people noted both in this trial and in workshops, that eating amaranth steamed on its own isn't how it would typically be consumed. However, adding flavouring would have masked the any differences between the varieties.

Pests and diseases

Hardly anybody's amaranth crops suffered any pests and diseases, except for slugs eating the plants at the seedling stage.

Overall ranking of varieties

We asked participants to provide an overall ranking of the 3 varieties, taking growth, yield and flavour into account. For each variety they were asked to rank it as first, second or third choice.

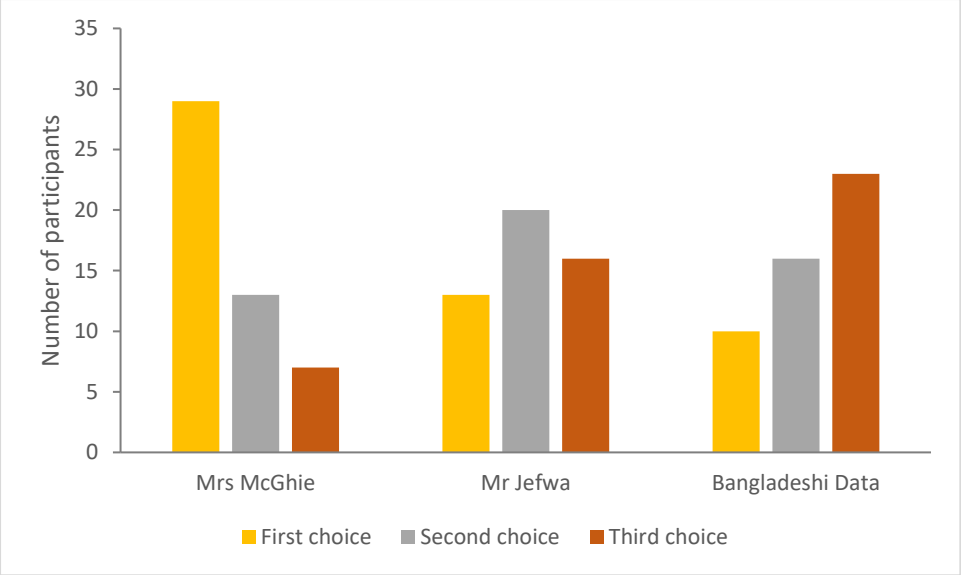


Figure 6 Ranking of varieties by participants

There were significant differences in preferences for the varieties (p= 0.0002) with most people ranking Mrs McGhie as their first choice. However, it is interesting that a significant minority also ranked Mr Jefwa and Bangladeshi as their first choice, demonstrating that it is important to maintain a diversity of varieties

Would they grow amaranth again?

Opinions were mixed as to whether this was a crop worth growing again, with just over half saying that they would consider growing it again. 43% said they were unlikely, 23% said they may consider it, 34% said they were likely to grow it again.

The comments paint a mixed picture, with some people very favourable towards the crop and others less favourable. The lack of pests and diseases were commonly mentioned as a favourable point. Some people found the flavour very bland, but the same could be said of other leafy crops. Some people found some interesting recipes to cook the product with and commented that they wish these had been sent with the protocols.

“My spinach chard always get leafminer so the amaranth did not, that was pleasing, but my spinach easier to harvest. The amaranth, much of it blew over in September as it was so tall, it was attractive to look at.”

“This crop was a revelation. Very easy to grow, no apparent pests or disease issues. The leaves were a very welcome addition to our diet. Amaranth will now join our roster of regularly grown vegetables.”

“I had not registered that it was a summer crop which is when we tend to eat lots of salad, so not many opportunity for cooking it. My husband was unimpressed but i tried. It was most acceptable in vegetable stir fry. It provoked a lot of discussion with fellow allotmenteers. Slugs left it alone.”

“I will try to grow amaranth again to double check on the disappointing taste . It may well be better tasting next time.”

"We noted that they were 'bland' but we found some excellent recipes to cook with them, and so they were a good green vegetable background to flavoured meals. They kept growing well into the autumn. We were still harvesting amaranth in mid-November when the survey ended. We did note they were prone to strong winds, which was improved by removing the flower heads and staking and putting garden string between - as you do for broad beans."

Conclusions

These set of results collected show that amaranth has the potential to be very productive as a leafy crop. Although our method of estimating yield was approximate, they generated some ballpark figures that could be compared with other studies. Currently there are few studies of leaf yields of amaranth in the UK, so this is useful information. The yields in this study ranged from 1 kg/ m^2 to 9 kg/m^2 with a couple of possible outliers of 20 and 35 kg/m^2. We were only able to find figures for amaranth leaf yields grown in warmer climates. Our yields compare favourably to equivalent ranges in the literature of 0.8 -3 kg in Tanazania (Mbwambo et al. 2015) and of 3 – 17 kg/m^2 in South Africa (Campbell and Abbott 1972). It is interesting that a few participants were able to achieve reasonable yields of 1.6 kg /m^2 in North East Scotland. One of the advantages of amaranth is that it is ready for the first harvest extremely quickly. Some studies reported that it was ready to harvest as quickly as 21 days after transplanting (Dinssa et al. 2018) in Tanzania. This rapid time from planting to harvest lends itself well to growing in the UK, even in more northerly climes where there can be quite a short window of warmer sunny weather for growing hot season crops. These leafy crops might even benefit from the longer days at more northern latitudes. This contrasts with many other hot season crops (eg sweet potatoes, gourds) that require a long growing season which can limit their productivity in the UK.

The other advantage was that amaranth was attacked by very few pests and diseases. Other equivalent UK leafy crops such as brassicas are heavily attacked by pests including pigeons, aphids, fleabeetle, butterflies and moths (Finch S. and Thompson A.R 1992). The other commonly grown leafy crops, chard and spinach are commonly attacked by leaf miners. (AHDB 2024), between April and October. Amaranth could fill this niche window very effectively, during a time, when chard is frequently spoilt by leaf miner. In warmer climates, Amaranth is not completely pest free as it is attacked by pests such as Amaranth Stem Weevil (Hypolixus truncatulus) and beet webworm (Spoladea revurcvalis) in warmer climates(Mbwambo et al. 2015), but luckily, these pests are not currently found in the UK.

When it came to choice of varieties, it was interesting that although there was a clear preference for Mrs McGhie, a clear minority also chose the other varieties, Bangladeshi Data and Mr Jefwa. This highlights the importance of maintaining a diverse collection to suit different locations, environments and cultural preferences. This is in line with the advice of the IPCC report on food security that stresses the importance of maintaining a diverse collection of seed varieties in order to tackle the future challenges of climate change (Mbow and Rosenzweig 2022).

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