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# Faba Bean: A Multipurpose Specialty Crop for the Mid-Atlantic USA

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## Introduction

Faba bean (*Vicia faba* L.), also known as fava bean, broad bean, horse bean, or Windsor bean, is a leguminous crop used as food, feed, forage, or cover crop in different parts of the world (Smither-Kopperl, 2019; figure 1).


Figure 1. Faba bean (A) plant on December 4, 2023, at the Tidewater Agricultural Research and Extension Center, Suffolk, VA, and (B) pods. Source for the image of pods: https://civileats.com/2017/01/12/modern-benefits-from-ancient-seeds-the-hunt-for-wild-fava-beans/

The global production of faba beans in 2022 was around 1,810,000 tons for green and 6,770,000 tons for dry bean, with total area harvested around 640,000 and 6,630,000 acres, respectively (FAOSTAT, 2024). Worldwide, faba bean production and harvested area is highest in Asia and Africa (figure 2). China and Ethiopia, the highest producers, contributed to around 28% and 18% of the global dry faba beans production in 2022, respectively. China and Ethiopia were the highest producers of dry faba beans in 2020 and 2021, too.

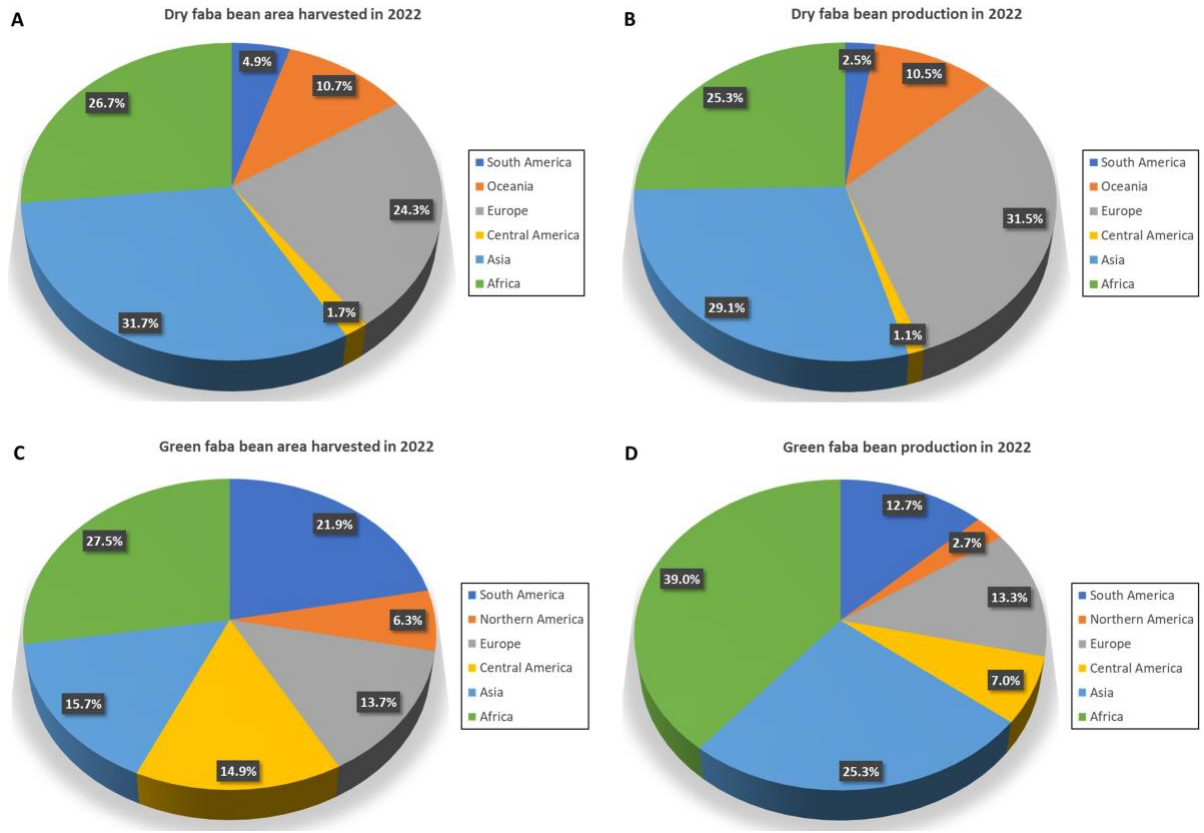


Figure 2. Regional contribution (%) to dry faba bean (A) area harvested and (B) production, and green faba bean (C) area harvested and (D) production in 2022 (FAOSTAT, 2024).

Similarly, Algeria and Egypt were the highest producers of green faba beans from 2020 to 2022, accounting for 17% and 9% of the global production in 2022, respectively. Although there are more than 50 faba bean-producing countries, the Middle East, China, Ethiopia, Egypt, Afghanistan, India, Northern Europe, and Northern Africa are the major producers (Dhull et al., 2022). The USA produced a little less than 50,000 tons of green faba beans, accounting for approximately 3% of the global production in 2020, 2021, and 2022, respectively (FAOSTAT, 2024). Close to 40,000 acres of land were harvested in the USA for green faba beans in 2020, 2021, and 2022, respectively.

# Why Faba Bean?

Based on the data compiled by Banaszkiewicz (2011), Griffiths and Lawes (1978), Hall et al. (2017), and Martineau-Côté et al. (2022) from several studies, the nutritional composition of faba bean is comparable to the other legumes (table 1). The crude protein content of faba bean (22-38%) is lower than that of soybean (32-43.6%) and lupin (32-44%), but significantly higher than for the other beans, including pea, lentil, chickpea, and other dry beans. Comparable to other leguminous crops such as lentils, beans, chickpeas, and peas, faba bean is rich in vitamins (Chávez-Murillo et al., 2018; Martineau-Côté et al., 2022; Raikos et al., 2014). The fat content of faba seed is lower than pea by 13% and soybean by 93%. Unlike soybean, faba bean is a non-genetically modified crop and not a regulated allergen (Calabrò et al., 2014; Health Canada, 2023). In addition to vitamins, proteins, and fat, faba bean contains a significant amount of dietary fiber in the range of 12.3-13.5% (Singh et al., 2017).

Table 1. Nutritional composition of faba bean as compared to other legumes. Crude protein has been expressed in % on dry weight basis. For carbohydrates, the total carbohydrate (TCH) and starch have been expressed in g/100 g dry weight and amylose as the % of total starch. The total, insoluble, and soluble dietary fibers, i.e., TDF, IDF, and SDF, have been expressed in g/100 g dry weight. Data has been compiled from Banaszkiewicz (2011), Griffiths and Lawes (1978), Hall et al. (2017), and Martineau-Côté et al. (2022).

| Legumes | Crude protein (%) | TCH (g/100 g) | Starch (g/100 g) | Amylose (%) | TDF (g/100 g) | IDF (g/100 g) | SDF (g/100 g) |
|---|---|---|---|---|---|---|---|
| Faba bean | 22.0-38.0 | 55.2-71.4 | 28.1-47.5 | 18.6-44.4 | 6.4-34.9 | 10.7-30.3 | 0.6-7.6 |
| Soybean | 32.0-43.6 | 19.7-33.2 | 0.2-6.7 | - | 13.7-35.5 | 15.4-32.6 | 0.6-6.1 |
| Kidney bean | 17.0-27.0 | 63.0-74.0 | 31.0-43.0 | 34.0-42.0 | 18.0-30.0 | 15.0-29.0 | 1.0-6.0 |
| Navy bean | 19.0-27.0 | 67.0-75.0 | 21.0-40.0 | 28.0-41.0 | 14.0-25.0 | 15.0-18.0 | 3.0-5.0 |
| Great northern bean | 23.0-27.0 | 69.0-71.0 | 18.0-37.0 | 31.0-42.0 | 20.0-21.0 | 15.0-16.0 | 5.0-6.0 |
| Pinto bean | 18.0-25.0 | 70.0-76.0 | 27.0-40.0 | 26.0-37.0 | 14.0-26.0 | 11.0-22.0 | 3.0-4.0 |
| Lentil | 23.0-31.0 | 42.0-72.0 | 37.0-59.0 | 19.0-25.0 | 7.0-23.0 | 11.0-19.0 | 1.0-7.0 |
| Cowpea | 24.0-28.0 | 42.0-63.0 | 35.0-52.0 | 14.0-20.0 | 11.0-34.0 | 11.0-30.0 | 1.0-4.0 |
| Chickpea | 19.0-27.0 | 52.0-71.0 | 30.0-56.0 | 23.0-28.0 | 6.0-15.0 | 10.0-18.0 | 1.0-8.0 |
| Pea | 14.0-31.0 | 55.0-72.0 | 30.0-49.0 | 23.0-49.0 | 3.0-20.0 | 10.0-20.0 | 2.0-9.0 |
| Lupin | 32.0-44.0 | 47.0 | 1.0-9.0 | 0 | 14.0-55.0 | 31.0-34.0 | 4.0-5.0 |

Although highly nutritious and like other legumes, faba bean has some anti-nutritional components in the seed such as phytic acid, vicine, convicine, saponins, lectins, raffinose, stachyose, tannins, and digestive enzyme inhibitors (Labba et al., 2021; Mattila et al., 2018; Sharma and Sehgal, 1992). To address this deficiency, many plant breeding and crop improvement programs are focused on improving the nutritional qualities of faba beans, thereby reducing the anti-nutritional content. Recently, new improved faba bean cultivars with low tannins, as well as low vicine and convicine contents have been developed (Hou et al., 2018; Khazaei et al., 2019). In addition to sustainable agricultural practices, faba bean cultivars can be used as food and animal feed.

# Faba Bean as a Food Crop

Globally, faba beans are used for diverse purposes. As a highly nutritious crop, it has found its place in various Mediterranean and Asian dishes such as *Falafel* (bean burger/deep fried dough), *Medammis* (stewed beans), *Nabet soup* (germinated boiled beans), and *Bissara* (poured paste) (Bakr, 1996; Dhull et al., 2022; Hamza et al., 1987). Green or dried beans, fresh or canned, can be used as vegetables and, in some countries, the roasted seeds are consumed as a snack (Gasim and Link, 2007; Singh et al., 2013). Faba bean flour can also be consumed in the form of gluten-free bread and spaghetti pasta. The gluten-free breads from unfermented and fermented faba bean flour were found to be more porous than soy flour bread by 34% and 18%, respectively (Sozer et al., 2019). Moreover, the addition of faba bean flour to corn in a 70:30 ratio can enhance the protein content of spaghetti by about 15% (Giménez et al., 2013). Every 10% addition of faba bean flour to the wheat flour enhanced the protein content of spaghetti by about 2.25% (Giménez et al., 2012). To meet the increasing demand for protein-rich foods and sustainable production, an increase in the supply of faba is required. Plant-based food systems being more

sustainable than animal-based can act as an alternative to the latter. The protein content of faba bean (25-40%) being higher than most of the pulse legumes, makes it an excellent source for plant-based food (Augustin and Cole, 2022; Chávez-Murillo et al., 2018; Hall et al., 2017). Similarly, due to the high protein content and increased demand for legume-based milk, faba bean can be used as an alternative to meat and milk (Augustin and Cole, 2022; Multari et al., 2015). For human consumption, the anti-nutritional content in faba bean can be reduced by several processing methods, such as soaking, cooking, autoclaving, germination, and extrusion (Dhull et al., 2022; table 2).

Table 2. Processing methods to reduce anti-nutritional contents in faba bean. The increase (+), decrease (-), and no change (0) in the anti-nutritional contents have been expressed as %. Data has been compiled from Alonso et al. (2000), Anderson et al. (1994), Dhull et al. (2022), Khalil and Mansour (1995), and Khalil (2001).

| Anti-nutritional factors | Soaking | Germination | Cooking | Autoclaving | Extrusion |
|---|---|---|---|---|---|
| Vicine | - | -27.9 | -35.3 | -39.7 | - |
| Convicine | - | -29.6 | -33.3 | -40.7 | - |
| Phytic acid | -27.0 | -75.0 | -40.0 | -49.0 | -26.7 |
| Raffinose | - | 0.0 | 0.0 | 0.0 | - |
| Stachyose | - | -100.0 | -47.0 | -21.0 | - |
| Tannins | +40.8 | -29.0 | -55.2 | -60.0 | -54.4 |
| Trypsin inhibitor | -4.5 | -31.9 | -71.5 | -84.4 | -98.9 |
| Chymotrypsin inhibitor | -8.4 | -12.1 | - | - | -52.8 |
| α-amylase inhibitor | -14.9 | -37.2 | - | - | -100.0 |

# Faba Bean as Animal Feed

In addition to human consumption, faba beans can be used for animal feed. For this purpose, faba bean seeds have similar or higher nutritional value than the other legumes (Meng et al., 2021; Mordenti et al., 2007). Although nutritious, the presence of anti-nutritional factors, in particular vicine and convicine, may affect the biological value of protein by decreasing its digestibility (Gnanasambandam et al., 2012). However, several breeding programs are focused on developing cultivars with low vicine and convicine content to make faba bean an alternative for other legumes for animal feed. Gous (2011) found that the broiler chickens fed with pelleted faba beans up to 250 g/kg showed no negative effect on birds' performance. The heat generated during the pelleting process destroyed the anti-nutritional components of the faba seed. Faba beans can be used as feed for cattles, bulls, and pigs, too. Addition of 30% of ground faba bean in the feed does not alter the feed consumption, milk production (>30 kg per cow per day), or milk composition (crude protein or lipid) of dairy cows (Brunschwig et al., 2002). Although the effect of faba bean on dairy cattle depends on the cultivar, even the cultivars with high anti-nutritional contents can also be used up to 20% in the feed without affecting the cow's daily milk yield, protein, and lactose production (Melicharová et al., 2009). Similarly, young bulls fed with faba bean concentrate-enriched feed instead of soy concentrate feed alone produced meat lower in fat, cholesterol, and total saturated fatty acid content (Calabrò et al., 2014). Faba bean is beneficial for cattle, bulls, and broiler chickens, but the studies suggested contradictory findings for pigs. Faba bean used up to 20% within the feed protein mixture did not affect pigs' performance; however, when used as the major source of protein or as complete soy replacement, results showed a linear reduction of pigs' growth rate (Brand et al., 1995; Castell, 1976). Overall, faba bean meal is a great source of protein and energy for ruminants, second after soybean meal (table 3).

Table 3. Protein and energy values for faba bean compared to other ruminant feed. The values are INRA quoted, compiled from O'Kiely et al. (2022) and Sauvant et al. (2004).

| Composition | Faba bean | Barley grain | Soybean meal | Pea seed |
|---|---|---|---|---|
| Crude protein (g/kg DM) | 302 | 116 | 539 | 240 |
| Digestible protein IA (g/kg DM) | 52 | 35 | 212 | 34 |
| Digestible protein IN (g/kg DM) | 192 | 80 | 395 | 150 |
| Digestible protein IE (g/kg DM) | 112 | 100 | 272 | 96 |
| Forage unit for milk production (per kg DM) | 1.2 | 1.1 | 1.21 | 1.2 |
| Forage unit for meat production (per kg DM) | 1.2 | 1.07 | 1.21 | 1.22 |
| Organic matter digestibility (%) | 91 | 83 | 93 | 92 |
| Metabolizable energy (MJ/kg DM) | 13.4 | 12.3 | 13.6 | 13.4 |

DM: Dry matter; Digestible protein IA: Digestible protein in the intestine of dietary origin; Digestible protein IN: Digestible protein in the intestine where nitrogen is the limiting factor for rumen microbial activity; Digestible protein IE: Digestible protein in the intestine where energy is the limiting factor for rumen microbial activity.

# Faba Bean for Sustainable Agricultural Practices

Faba bean, being a leguminous crop, can fix atmospheric nitrogen in the soil, thus improving soil fertility. Compared to the other cool-season legumes such as pea and lupin, faba bean can attain and fix more nitrogen from the atmosphere to soil (Hardarson et al., 1991; Hauggaard-Nielsen et al., 2009; Jensen et al., 2010; Peoples et al., 2009). Therefore, it can be planted as a cover crop or in rotation with other non-leguminous crops, thus minimizing additional nitrogen requirement by the latter and contributing to agricultural sustainability. Faba bean planted in rotation in a no-till system can also reduce greenhouse gas emissions from the cultivated land (Sarauskis et al., 2020). It can be planted as a main or cover crop, for dual purpose cropping systems (Brasier et al., 2023; Etemadi et al., 2019). Regardless of the cropping system, after pod harvest, remaining biomass can be incorporated into the soil or left on the soil surface, depending on the type of tillage, thus improving soil nitrogen and organic matter availability, a credit for the following crops. In addition, legumes such as faba bean and pea can reduce nitrogen leaching from the soil by scavenging the residual nitrogen with shoot uptake values of 92-276 and 104 kg N ha-1, respectively (Hauggaard-Nielsen et al., 2009). Faba bean also increased soil phosphorus availability by forming mycorrhizal associations in soils. Being a host to some aphid species, such as black bean aphid, it can be used in integrated pest management (Köpke and Nemecek, 2010) by attracting predatory insects feeding on aphids (Stoddard et al., 2010). Intercropping faba bean as a component of integrated pest management can protect the main crop and reduce the use of insecticides, thus contributing to environmental sustainability.

# Why Mid-Atlantic USA?

Faba bean is a cool-season crop that can grow well in the Mid-Atlantic during winter. Although temperatures ranging from 60-65 °F are the best for its growth, faba bean can grow at temperatures ranging from 45-75 °F, with varieties that can withstand frosts and freezes (Etemadi et al., 2015). As temperatures are expected to increase by 2.7 °F by 2050 and 3.6-7.2 °F by 2100 (Collins et al., 2013), and frequently exceed the optimum temperature for growth and development of summer crops, winter-hardy cultivars of faba can ensure cropping system diversification while minimizing the negative effects of summer heat on crop yield (Ramsey et al., 2022). This will ensure more sustainable crop production in the Mid-Atlantic. If grown for green or dry seed in addition to cover crop, winter faba bean can also improve the economic profitability of this region. In terms of soil requirements, faba bean can grow in a wide range of soils, but well-drained and slightly acidic soils with pH around 6.0 are the best suited for faba

production (Etemadi et al., 2015). The agricultural land of the Mid-Atlantic has soils that check both requirements for drainage, most soils are loams and sandy-loams, and acidity, most soils are slightly acidic with pH ranging from 5.5-6.5 (Abaye et al., 2006), making this region a favorable home for faba bean cultivation.

# Faba Bean Research at the Tidewater Agricultural Research and Extension Center in Virginia

A USDA-funded project at the Virginia Tech' s Tidewater Agricultural Research and Extension Center (TAREC) in Suffolk, VA, is focused on introduction of faba bean as a winter seed crop with multiple benefits for the Mid-Atlantic cropping systems. The project includes collaborators from the University of Maryland, University of Delaware, North Carolina State University, and University of Georgia, in addition to the Virginia State University and Virginia Tech. Started in 2023 and lasting until 2027, the project will address objectives related to cultivar development through breeding, genetics and physiological strategies, identification of the best agronomic practices to maximize yield and economic return, economic and marketing logistics, and consumer acceptance. Currently, 500 varieties of faba bean from 50 countries are being tested for cold tolerance in Georgetown, DE, and Petersburg and Suffolk, VA (table 4).

Table 4. Number of faba bean varieties from different parts of the world planted at the Tidewater Agricultural Research and Extension Center, Suffolk, VA, Virginia State University, Petersburg, VA, and Carvel Research and Education Center, Georgetown, DE. The number of varieties planted in these three locations varies from 492-504. At Suffolk, VA, 504 varieties are being tested.

| Country | Number of entries | Country | Number of entries | Country | Number of entries |
|---|---|---|---|---|---|
| Afghanistan | 12 | Georgia | 3 | North Macedonia | 7 |
| Argentina | 1 | Germany | 4 | Pakistan | 20 |
| Armenia | 1 | Greece | 2 | Peru | 15 |
| Australia | 1 | Hungary | 21 | Poland | 2 |
| Belgium | 1 | India | 2 | South Africa | 1 |
| Bolivia | 3 | Iran | 28 | Soviet Union | 6 |
| Bulgaria | 3 | Iraq | 9 | Spain | 19 |
| Canada | 10 | Israel | 6 | Sudan | 2 |
| Chile | 2 | Italy | 6 | Sweden | 1 |
| China | 100 | Japan | 1 | Syria | 4 |
| Colombia | 1 | Jordan | 1 | Taiwan | 1 |
| Cyprus | 1 | Kenya | 11 | Tajikistan | 24 |
| Ecuador | 3 | Kyrgyzstan | 1 | Turkey | 25 |
| Egypt | 6 | Mexico | 1 | United Kingdom | 18 |
| Ethiopia | 8 | Morocco | 12 | USA | 75 |
| Finland | 2 | Nepal | 5 | Yemen | 2 |
| France | 8 | New Zealand | 1 | N/A | 5 |

Throughout the winter, stand count, frost damage and plant survival were periodically recorded. As of mid-March 2024, survival rate was over 75%, with more than 50% of varieties starting to bloom as soon as early December 2023 (figure 3).

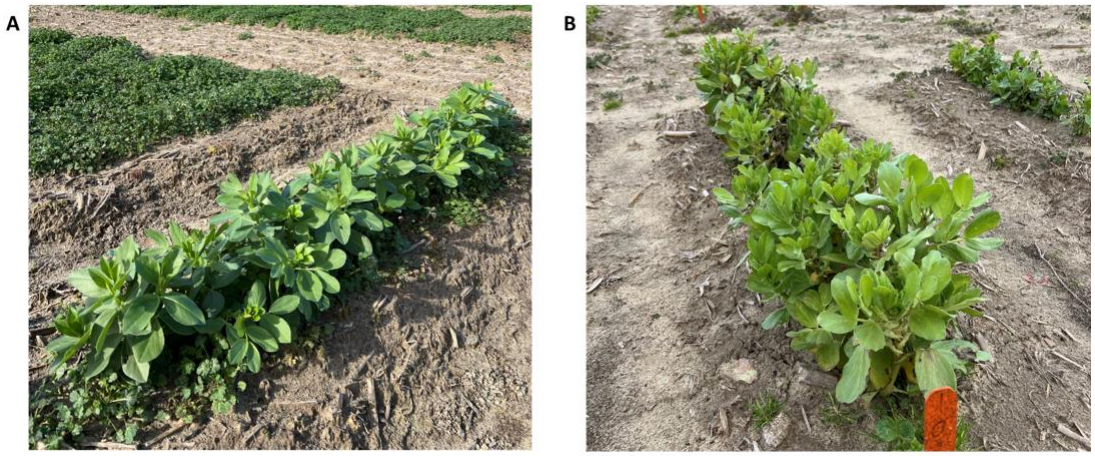


Figure 3. Faba bean research plots at the Tidewater Agricultural Research and Extension Center, Suffolk, VA, on (A) December 4, 2023, and (B) January 29, 2024, when faba varieties received 1303 °F and 2028 °F, respectively, heat units or growth degree days (GDD).

Insect and disease ratings were taken by collaborating researchers, Drs. Alejandro Del-Pozo (Hampton Roads AREC) and Doug Higgins (Eastern Shore AREC) and their graduate students. A drone was flown repeatedly over the plots at all locations and, from collected and processed images, information on plant growth and development will be derived (figure 4). Finally, the most yielding and healthier varieties will be selected for further in-depth agronomic research in response to the common pests and production practices of the region. As the results became available, the PI will provide updates. An Advisory Committee will help the researchers to stay engaged with growers and stakeholders on faba production, management, and use for its successful introduction as a multipurpose crop in the Mid-Atlantic USA.

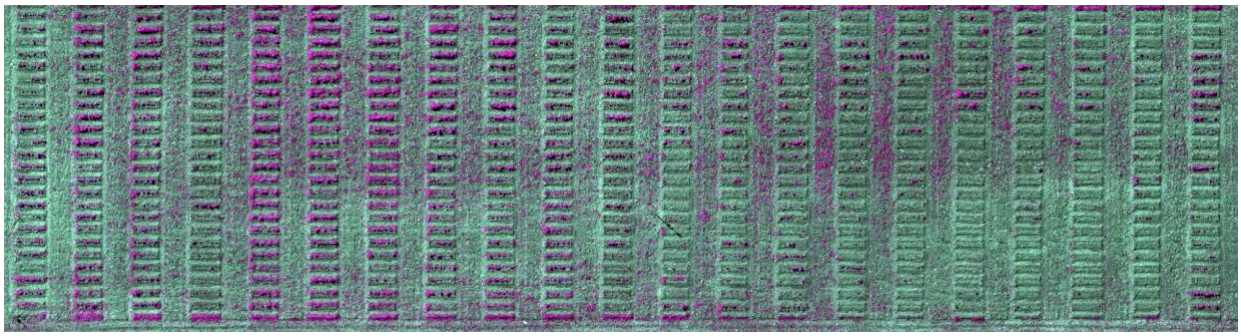

Figure 4. Faba bean research plots at Tidewater Agricultural Research and Extension Center, Suffolk, VA, on February 29, 2024, shown in a false color composite (near-infrared-red-red edge). Plots of faba bean representing individual varieties are colored in pink. Varieties with the most biomass accumulation and vigor are shown in the most intense pink color, whereas the green plots represent dead varieties.

## Acknowledgements

The research project at the Tidewater Agricultural Research and Extension Center is funded by the USDA Specialty Crops Research Initiative, grant number 13881197.

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2024/VCE-590NP