agriculture

Supplementary Data

CARINATA GROWTH STAGES

Growth Stage 0: Germination
0.0 Dry seed
0.1 Beginning of seed imbibition
0.3 Seed imbibition complete
0.5 Radicle emerged from seed
0.7 Hypocotyl with cotyledons breaking through seed coat
0.9 Emergence: cotyledons break through soil surface

Growth Stage 1: Leaf development (Main shoot)
1. 0 cotyledons completely unfold
1.1 first true leaf unfolds
1.2 two leaves unfold
1.3 three leaves unfold
1.4 four leaves unfold
1.5 five leaves unfold
1.6 six leaves unfold
1.7 seven leaves unfold
1.8 eight leaves unfold
1.9 nine or more leaves unfold

Growth Stage 2
This growth stage (2.0-2.9) refers to the development of side shoots (tillering) and occurs in many plant species but it is not applicable to carinata.

Growth Stage 3: Stem Elongation
3.0 stem elongation (bolting) begins
3.1 stem 10% of final length
3.2 stem 20% of final length
3.3 stem 30% of final length
3.4 stem 40% of final length
3.5 stem 50% of final length
3.6 stem 60% of final length
3.7 stem 70% of final length
3.8 stem 80% of final length
3.9 maximum stem length

Growth Stage 4
This growth stage (4.0-4.9) is not important for carinata but applies in the development of harvestable vegetative plant parts such as broccoli or cauliflower.

Growth Stage 5: Inflorescence emergence
5.0 flower buds present, but still enclosed by leaves
5.1 flower buds visible from above (green bud)
5.2 flower buds free, level with the youngest leaves
5.3 flower buds raised above the youngest leaves
5.5 individual flower buds (main inflorescence) visible but still closed
5.8 individual flower buds (secondary inflorescence) visible but closed
5.9 first petals visible, but flower buds still closed (yellow bud)

Growth Stage 6: Flowering
6.0 First flowers open (sporadically)
6.1 Beginning of flowering: 10% of flowers open
6.2 20% of flowers open
6.3 30% of flowers open
6.4 40% of flowers open
6.5 Full flowering: 50% of flowers open
6.7 Flowering finishing: majority of petals fallen or dry
6.9 End of flowering

Growth Stage 7: Fruit/Pod development
7.1 First fruits formed
7.2 20% of fruits have reached typical size and hard
8.5 50% of the fruits ripe, or 50% of seeds of typical color, dry and hard
8.9 Fully ripe: seeds on the whole plant of typical color and hard

Growth Stage 9: Senescence
9.2 Leaves and shoots beginning to discolor
9.5 50% of leaves yellow or dead
9.7 Plants or above ground parts dead
9.9 Harvested product (seeds)

Figure S1. Categorization of the growth stages of Brassica carinata based on life stage and development from germination to senescence developed by the South East Partnership for Advanced Renewables from Carinata (SPARC).

Figure S2. Boron deficiency in *Brassica carinata* first manifested as a general distortion of the upper leaves. Note that the distortion resulted in folding of the leaves rather than as curling, cupping, or withering of the leaf surface. This folding was concentrated along the margin and midrib similar to the leaf was being folded in half lengthwise.

Figure S3. As boron deficiency symptomology in Brassica carinata progressed, the folding became more severe, especially on new foliage. The newest foliage appeared rolled on itself like a tube of paper. This rolling is different than the cupping of the leaves observed in calcium deficient leaves because the whole leaf blade curls from the midrib to the margin whereas calcium deficiency results in only the leaf margin curling in and downward.

Figure S4. As symptoms of boron deficiency progressed in Brassica carinata, the new leaves exhibited cracking along the midrib and petiole. This leaf curling along with the cracking are classical boron deficiency symptoms.

Figure S5. In the advanced stages of boron deficiency, the apical meristem becomes necrotic and eventually dies in Brassica carinata. This results in the proliferation of axillary shoots as the plant continues to grow.

Figure S6. Boron deficiency in Brassica carinata will eventually result in the death of the apical meristem. This sudden loss of apical dominance results in the axillary shoot growth, resulting in numerous axillary shoots. Note the dense cluster of side shoots around the dead growing tip.

Figure S7. Iron deficiency symptoms in Brassica carinata were present in the rosette stage for Brassica carinata and were quite severe in the lowest (0.0 μmol Fe • L^{-1}) fertility treatment resulting in newer and developing leaves which had interveinal chlorosis.

Figure S8. Symptoms of iron deficiency in Brassica carinata were present at the lowest fertility treatment (0.0 μmol • L^{-1}) at both the flowering (top) and pod set (bottom) stages.

Figure S9. Initially, this Brassica carinata plant appeared healthy and vigorous. As the plant grew out of its rosette phase and into the beginning phases of elongation/bolting before zinc deficiency symptoms began to appear.

Figure S10. The beginning stages of zinc deficiency in Brassica carinata appeared very late in the experiment as a marginal paleness and purpling of the leaf margin especially of the leaf tip. Also note the gall like structures on the leaf surface. When diagnosing Zn deficiency these two symptoms are unique symptomologies.

Figure S11. The Brassica carinata plant on the left received all its essential macro and micronutrients while the plant on the right is exhibiting manganese deficiency symptoms. Note specifically the pale coloration of the plant especially along the upper mature leaves.

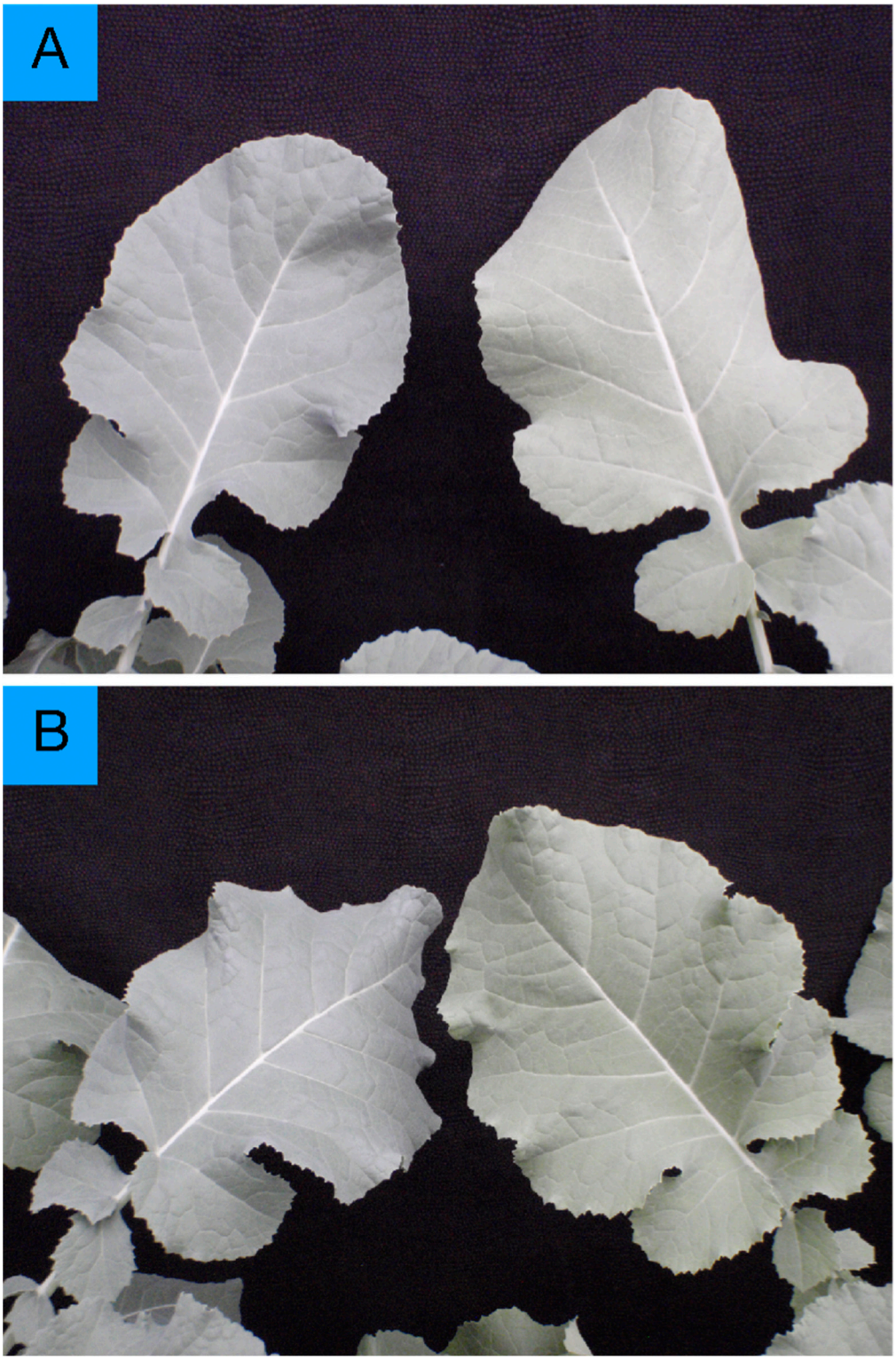

Figure S12. Manganese deficient Brassica carinata plants resulted in a pale coloration (right leaf, A and B) compared with non-deficient leaf (left leaf A, B). The coloration was more developed in the upper (A) and mid (B) foliage of the plant.