Nutrition

If the nutrients (phosphorus, nitrogen, zinc, etc.) removed as grain from the paddock are not replaced then crop yields and soil fertility will fall.

This means that fertilizer inputs must be matched to expected yields and soil type. The higher the expected yield, the higher the fertilizer input, particularly for the major nutrients, phosphorus, potassium and sulphur.

Balancing Inputs

A balance sheet approach to fertilizer inputs is a good starting point in considering the amount of fertilizer to apply to your pulse crop. Other factors such as soil type, paddock history, soil test and tissue analysis results, as well as your own experience all affect the choice of fertilizer to be used.

The nutrients removed by one tonne of grain by the various pulses is shown in Table 4:A. Actual values may vary by 30% or sometimes more, due to the differences in soil fertility, varieties and seasons. For example, the phosphorus per tonne removed by faba bean grain can vary from a low 2.8 kg on low fertility soils to 5.4 kg on high fertility soils.

From the table it can be seen that a 3 t/ha crop of faba beans will remove (on average) 12 kg/ha of phosphorus. This then is the minimum amount of phosphorus that needs to be replaced. Higher quantities may be needed to build up soil fertility or overcome soil fixation of phosphorus.

So, the removal table is a guide. Soil types do vary in their nutrient reserves. For example, most black and red soils have sufficient reserves of potassium to grow many crops. However, the light, white sandy soils which, on soil test, have less than 50ppm (Bicarb test) of potassium will respond to applications of potassium fertilizer. Other soils may have substantial nutrient reserves which vary in availability during the growing season or are unavailable due to the soil's pH. This can often be the case with micro-nutrients. Foliar sprays can be used in these cases to correct any micro-nutrient deficiencies.

Table 4:A

(revised 1994)
Nutrients removed by 1 tonne of:

	Kilograms						Grams		
Grain	**N**	**P**	**K**	**S**	**Ca**	**Mg**	**Cu**	**Zn**	**Mn**
Pulses									
Chickpeas (Desi)	33	3.2	9	2.0	1.6	1.4	7	34	34
Chickpeas (Kabuli)	36	3.4	9	2.0	1.0	1.2	8	33	22
Faba Beans	41	4.0	10	1.5	1.3	1.2	10	28	30
Lentils	40	3.9	8	1.8	0.7	0.9	7	28	14
Lupins (Sweet)	53	3.0	8	2.3	2.2	1.6	5	35	18
Lupins (White)	60	3.6	10	2.4	2.0	1.4	5	30	60
Peas (Field)	38	3.4	9	1.8	0.9	1.3	5	35	14
Cereals									
Wheat	23	3.0	4	1.5	0.4	1.2	5	20	40
Barley	20	2.7	5	1.5	0.3	1.1	3	14	11
Oats	17	3.0	5	1.6	0.5	1.1	3	17	40

Nutrient Budgeting

When grain is harvested from the paddock, nutrients are removed in the grain. If, over time, more nutrients are removed than are replaced (via fertilizer) then the fertility of the paddock will fall.

Nutrient budgeting is a simple way to calculate the balance between nutrient removal (via grain) and nutrient input (via fertilizer)

The following table uses standard grain nutrient analyses from Table 4:A . For a more accurate guide to nutrient removal use analysis of grain grown on your farm. The best picture emerges when several years of a rotation are budgeted.

Table 4:B

An example of nutrient budgeting

Year	Crop	Yield t/ha	Nutrients removed N	P	K	S
1994	Faba beans	2.2	90	8.8	22	3.3
1995	Wheat	3.8	87	11.4	15	5.7
1996	Barley	4.2	84	11.3	21	6.3
1997	Chickpeas	1.8	59	5.8	16	3.6
		Total	**320**	**37.3**	**74**	**18.9**
Year	**Fertilizer**	**Rate t/ha**	**Nutrients applied kg/ha N**	**P**	**K**	**S**
1994	0:20:0	50	0	10	0	1
1995	18:20:0	70	12.6	14	0	1
1996	18:20:0	70	12.6	14	0	1
	Urea	60	27.6	0	0	0
1997	0:16:0:20	80	0	12.8	0	16
		Total	**52.8**	**50.8**	**0**	**19**
Balance			**-267.2**	**+13.5**	**-74**	**=**

As can be seen from Table 4:B a simple nutrient budget, there needs to be some interpretation of a nutrient budget.

Nitrogen: the deficit of 267 kg needs to be countered by any nitrogen fixation that occurred.

TABLE 4:C **Fertilizer Application Rate Ready Reckoner (all rates can be read as lb/ac or kg/ha)**

Phosphorus	Some of the fertilizers used on Pulses															
	Superphosphates						6:16:0:10 Legume Special			10:22:0 M.A.P.		18:20:0 D.A.P.		0:15:0:7 Grain Legume Super	
	Single 8.6% P		Gold-Phos 10 18% P		Triple 20% P										
	fert	S	fert	S	fert	S	fert	N	S	fert	N	fert	N	fert	S
10	116	13	50	5	45	.7	62	4	6	46	5	50	9	69	5
12	140	15	67	7	60	.9	75	4	8	55	6	60	11	83	6
14	163	18	78	8	70	1.1	87	5	9	64	6	70	13	97	7
16	186	20	89	9	80	1.2	99	6	10	73	7	80	14	110	8
18	209	23	100	10	90	1.4	112	6	11	82	8	90	16	124	9
20	223	25	111	11	100	1.5	124	7	12	91	9	100	18	138	10
22	256	28	122	12	110	1.7	137	8	14	100	10	110	20	152	11
24	279	31	133	13	120	1.8	149	8	15	110	11	120	22	166	12

This may have been 50 kg/ha per legume crop. It still shows that the nitrogen status of the soil is falling and should be increased by using more nitrogen in the cereal phase.

Estimating nitrogen fixation is not easy. One rule to use is: - 20 kg of nitrogen is fixed for each tonne of plant dry matter at flowering.

Phosphorus: The credit of 13 kg will be used by the soil in building phosphorus levels, hence increasing soil fertility. No account was made for soil fixation of phosphorus.

Potassium: Because most Australian soils have plenty of potassium, drawing down the levels without replacing any potassium is quite legitimate. However some Australian cropping soils (usually white sandy soils) are showing responses to potassium and applications should be considered to at least replace the potassium used by the crop.

Sulphur: The sulphur inputs and removals are in balance.

Obviously other nutrients such as zinc and copper can also be included in a nutrient balancing exercise. This is a useful tool for assessing the nutrient balance of a cropping rotation, however it needs to be considered in conjunction with other nutrient management tools such as soil and tissue testing, soil type, soil fixation and potential yields.

As phosphorus is the basis of soil fertility and hence crop yields, all fertilizer programmes are built on the amount of phosphorus needed. Table 4:C shows the phosphorus rates and the rates of various fertilizers needed to achieve this.

There are many fertilizers available to use on pulses, for the best advice check with your local fertilizer reseller or agronomist.

In recent years there has been a trend to using 'starter' fertilizers such as M.A.P. and D.A.P. on pulses. Some growers are worried that using nitrogen on their pulse crop will affect nodulation. This is not the case with the low rates of nitrogen as supplied by M.A.P. or D.A.P.. A benefit from using the starter nitrogen is that early plant vigour is often enhanced and on low fertility soils yield increases have been gained.

Detecting Nutrient Deficiencies.

It is commonly believed that a soil or plant tissue test will show how much nutrient is required by the plant. **This is not so.** A soil test will only show that at a certain soil concentration, the plant will or will not respond to that nutrient. These tests are very specific for both the soil type and the plant being grown.

Experience suggests that the only worthwhile soil tests will be for phosphorus, potassium, organic matter, soil pH and soil salt levels. Recently a new sulphur test has been developed.

The pulse crops can have different requirements for potassium, hence different soil test K critical levels. *(See Table 4 : D.2)*

TABLE 4 : D
Adequate levels for various soil test results.

D.1. **Phosphorus**

	Colwell	Olsen
Sand	20 - 30	10 - 15
Loam	25 - 35	12 - 17
Clay	35- 45	17 - 23

D.2. **Potassium**

	Bicarb	Skene	Exchangeable K
Sand	50	50	Not applicable
Other soils	100	100	0.25 me/100g
Sandy Loam			
- faba beans	100 - 120	-	-
- field peas	70 - 80	-	-
- lupins	30 - 40	-	-

D.3. **Sulphur**

	KCl
Low	5 ppm
Adequate	8 ppm

Plant tissue testing can also be used to diagnose a deficiency or monitor the general health of the pulse crop. Plant tissue testing is most useful for monitoring crop health, because by the time noticeable symptoms appear in a crop the yield potential can be markedly reduced.

Several companies perform plant tissue analysis and derive very accurate analytical concentrations however it can be hard to interpret the results and determine a course of action. As with soil tests, different plants have different critical concentrations for a nutrient. In some cases varieties can vary in their critical concentrations.

Tables 4:F to 4:J list the plant analysis criteria for pulse crops. These should be used as a guide only.

Care should be taken to use plant tissue tests for the purpose for which they have been developed. Most tests diagnose only the nutrient status of the plants at the time they are sampled and cannot reliably indicate the effect of a particular deficiency on grain yield.

Nutrient Toxicity

The pH of a soil has an affect on the availability of most nutrients. Occasionally some nutrients are made so available that they inhibit plant growth. For example on some acid soils, aluminium and manganese levels may restrict plant growth, usually by restricting the rhizobia and so the plants ability to nodulate.

Boron toxicity *(See Plates 4:A, B & C)* occurs on many of the alkaline soils of the southern cropping areas. The most characteristic symptom of boron toxicity in pulses is chlorosis, and some necrosis if severe, at the tips or margins of the leaves. The older leaves are usually more affected. At this stage there appears to be little difference in reaction between the current varieties.

TABLE 4 : E
Pulse reactions to nutrient toxicities

	Boron	Aluminium	Manganese
Chickpeas	sensitive	very sensitive	very sensitive
Faba Beans	tolerant	sensitive	sensitive
Lentils	very sensitive	very sensitive	very sensitive
Lupins	*	tolerant	tolerant
Field Peas	sensitive	sensitive	sensitive

* this crop not usually grown on alkaline - high boron soils.

Specific Nutrient Problems

CHICKPEAS

Information for this crop is still limited (1998) however the nutrient deficiency symptoms would be similar to those described for the other pulses. (*See Plate 28.*)

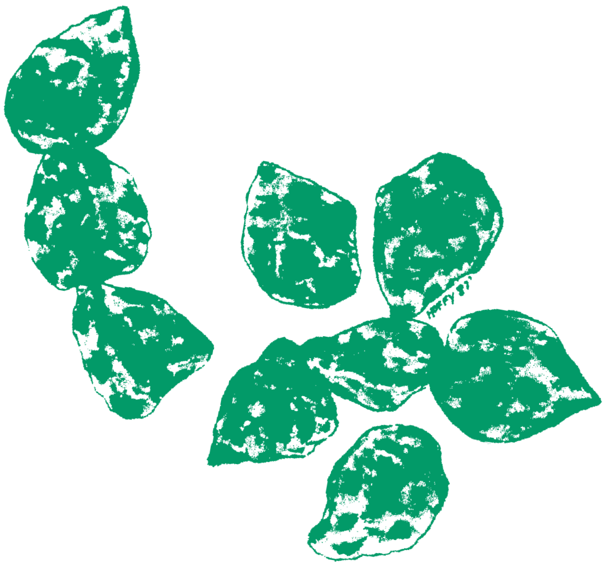
TABLE 4:F

Critical nutrient levels for chickpeas at flowering

Nutrient	Plant Part	Critical Range *
Nitrogen(%)	Whole shoot	2.3
Phosphorus(%)	Whole shoot	0.24
Potassium (%)	YML**	1.5
Sulphur(%)	Whole shoot	0.15 - 0.20
Boron(mg/kg)	Whole shoot	40
Copper(mg/kg)	Whole shoot	3
Zinc(mg/kg)	Whole shoot	12

*Any nutrient level below the critical range will be deficient; any level above will be adequate.

**YML = youngest mature leaf.



FABA BEANS

Faba beans have a high phosphorus requirement. Phosphorus should be applied at rates of at least 12 and up to 22 kg/ha for this crop. (See Table 4:C for fertilizer rates) On black soils of pH8, zinc deficiencies can be caused by these high phosphorus rates. Zinc can be applied either with the fertilizer at sowing or as a foliar spray.

Faba beans appear to be more susceptible to potassium deficiency compared with other pulses like peas and especially lupins.

Deficiency Symptoms

Phosphorus	leaves are dark green, older leaves drop, the stems are thin and blossoms sparse.
Potassium	older leaflets show a slight curling and then a distinct greying of leaf margins, eventually dying.
Sulphur	youngest leaves turn yellow, plants are slender and small.
Iron	yellowing between leaf veins can progress to completely yellow plants.
Manganese	young leaves first show chlorosis, followed by small dead spots at each side of the mid-rib and lateral veins. The leaves can turn yellow and die.
Molybdenum	leaves are pale green and mottled between veins, with brown scorched areas developing rapidly between veins.
Zinc	plants are small, the areas between veins turn yellow, becoming yellower on the lowest leaves. Maturity can be delayed.

TABLE 4:G

Critical nutrient levels for faba beans at flowering

Nutrient	Plant Part	Critical Range *
Nitrogen(%)	YOL**	4.0
Phosphorus(%)	YOL	0.4
Potassium(%)	YML***	1.0
Calcium(%)	YML	0.6
Magnesium(%)	YML	0.2
Sulphur(%)	whole shoot	0.2
Boron(mg/kg)	YOL	10
Copper(mg/kg)	YML	3.0 - 4.0
Manganese(mg/kg)	YML	<40
Zinc(mg/kg)	YOL	20 - 25

*Any nutrient level below the critical range will be deficient; any level above will be adequate.

**YOL = youngest open leaf blade.

***YML = youngest mature leaf.

LENTILS

At this stage (1998) there is very little nutritional information about lentils in Australia. The symptoms of nutrient deficiency would be similar to the other pulses.

TABLE 4:H

Critical nutrient levels for lentils at flowering

Nutrients	Plant Part	Critical Range *
Phosphorus(%)	YML**	0.3
Potassium(%)	YML	1.8
Sulphur(%)	YML	0.2
Boron(mg/kg)	YML	20
Copper(mg/kg)	YML	3
Zinc(mg/kg)	YML	20

*Any nutrient level below the critical range will be deficient; any level above will be adequate.

**YML = youngest mature leaf.

LUPINS

Deficiency Symptoms

Phosphorus — plants have narrow stems and petioles and form few laterals. As the deficiency progresses the older leaves turn grey-green and may fall. *(See Plate 17.)*

Potassium — symptoms are first seen on old leaves. These become chlorotic with dark dead looking tips which eventually fall. *(See Plate 18.)*

Sulphur — symptoms look like nitrogen deficiency. Plants are pale green in color and slow in growth. Older leaves become bright yellow. *(See Plate 19, 4:D & 4:E.)*

Copper — no visual symptoms produced by narrow leafed lupins when grown in a copper deficient situation.

Iron — the youngest leaves and new growth become extremely chlorotic (an even bright yellowness over the entire leaf) under iron deficiency. The middle leaves which develop chlorosis more slowly, produce small brown necrotic spots between the margins and the mid-rib of the leaflets. *(See Plates 23,24 & 27.)*

Manganese — lupins rarely suffer from manganese deficiency before flowering but have a strong demand for this nutrient as seeds develop and mature. Manganese deficiency can influence seed development and cause split or shrivelled seed in pods. Deficient plants remain green longer which can cause severe difficulties at harvest. Leaves rarely show symptoms but in extreme cases unopened new leaves are pale green with small dead spots on the tips of the leaflets. *(See Plate 20.)* Manganese deficiency can be overcome easily by applying foliar manganese at the rate of 1kg of manganese per hectare during flowering. This manganese spray must be applied at mid-flowering of the first lateral. By this stage of growth the first pods on the main stem will be 2 to 2.5 cm long. *(See Plates 21 & 22.)*

Molybdenum — results in paling because of nitrogen fixing problems and can also cause reduced growth and delayed flowering. *(See Plate 25.)*

Zinc — deficiency symptoms appear in young leaves which are pale and form in rosettes. Brown spots may appear on the mid-rib of new leaves. *(See Plate 26.)*

TABLE 4:I

Critical nutrient levels for sweet lupins at flowering

Nutrients	Plant Part	Critical Range *
Phosphorus(%)	YML**	0.20
Potassium(%)	YML	1.5
Sulphur(%)	Whole shoot	0.20 - 0.25
Magnesium (%)	YML	0.17
Boron(mg/kg)	YML	15
Copper(mg/kg)	YML	3.0
Manganese(mg/kg)	Stem***	20
Zinc(mg/kg)	YML	12 - 14

*Any nutrient level below the critical range will be deficient; any level above will be adequate.

**YML = youngest mature leaf.

***Stem = stem at primary bud stage.

PEAS

Like all pulses peas require high levels of phosphorus for growth and also remove large amounts of phosphorus in the grain.

Deficiency Symptoms

Phosphorus — leaves are bluish-green and sparse, the leaves are weak, thin and stunted.

Potassium — leaves become dark green with yellowing and fining of the lower leaves at margins. The leaflets are cupped downward, the pods are poorly filled and growth generally is retarded.

Sulphur — younger leaves including the veins turn yellow, in severe deficiency situations the older leaves also turn yellow, the plants tend to be small and slender.

Copper — terminal stem tips become wilted, the basal buds are green with weak side growth while flowers abort without forming pods.

Manganese — leaves show a slight chlorosis (yellowing) between the veins and seeds may have a brown spot or cavity in the centre (marsh spot).

Iron — iron deficiency causes yellowing between the veins, progresses to severely yellowed or chlorotic leaves, caused by complete absence of green chlorophyll *(See Plate 29.)* Crops growing on high pH black clay soils may develop both iron and manganese deficiencies. Foliar sprays have been used to treat both deficiencies successfully.

Molybdenum — plants become pale yellow because the deficiency interferes with nitrogen fixation.

Zinc — lower leaves become brown and dead around the edges and tips while stems are stiff and erect; flowers are reduced.

TABLE 4:J

Critical nutrient levels for field peas at flowering

Nutrient	Plant Part	Critical Range *
Nitrogen(%)	YML**	3.5
Phosphorus(%)	YML	0.25 - 0.30
Potassium(%)	YML	1.5 - 2.0
Calcium(%)	YML	0.6
Magnesium(%)	YML	0.2
Sulphur(%)	whole shoot	0.2
Boron(mg/kg)	YML	20
Copper(mg/kg)	YML	3.0 - 5.0
Manganese(mg/kg)	YML	30
Zinc(mg/kg)	YML	18

*Any nutrient level below the critical range will be deficient; any level above will be adequate.

** YML = youngest mature leaf.

Note 1: All of the above critical levels relate to vegetative growth, at flowering.

Note 2: There are two particularly good reference books available from Soil Science and Plant Nutrition, School of Agriculture, University of Western Australia, Nedlands, W.A. 6009.

- Symptoms of Nutrient Deficiencies in Lupins
- Symptoms of Nutrient Deficiencies in Faba beans and Field peas.

Some of the nutrient deficiency plates in this handbook are from the above books with the kind permission of Kevin Snowball and Alan Robson.

Note 3: For further information on interpreting tissue analysis; refer to the second addition of 'Plant Analysis' by Reuter and Robinson.

Plate 17

Phosphorus deficiency in narrow leafed lupins. Note the decreased growth and leaf fall in the plant on the right.

Plate 18

Potassium deficiency in narrow leafed lupins (left). Severe leaf fall can occur. Plant on right has adequate potassium.

Plate 19

Leaves of narrow leafed lupins showing symptoms of sulphur deficiency in the older leaves of the plant. Leaf on left is sulphur adequate.

Plate 20

Manganese deficiency (severe) of the younger leaves of narrow leafed lupins.

Plate 21

Manganese deficiency in lupins. The ripe crop (left) has been sprayed with manganese. Deficient plants (right) are delayed in their ripening making harvest difficult where the deficiency occurs in patches.

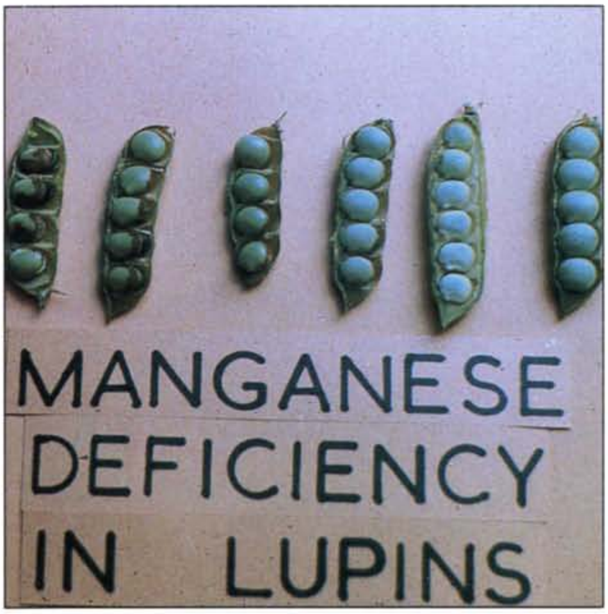


Plate 22

Manganese deficiency in lupins, showing the effects on the seed from severe (left) to unaffected (right). Note the brown growth on the severely affected seeds.

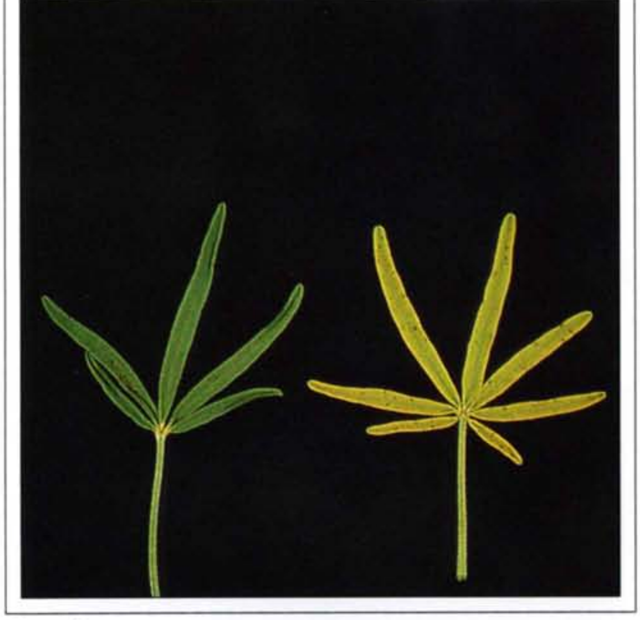


Plate 23

Symptoms of magnesium (left) [old-to-middle leaves] and iron (right) [middle-to-new leaves] deficiencies in leaves.

Plate 24

Symptoms of magnesium (left) [old-to-middle leaves] iron (centre) and manganese (right) [middle-to-new leaves] deficiencies, in single leaflets of narrow leafed lupins.

Plate 25

Molybdenum deficient (left) and molybdenum sufficient (right) narrow leafed lupins.

Plate 26

Symptoms of severe zinc deficiency in narrow leafed lupins.

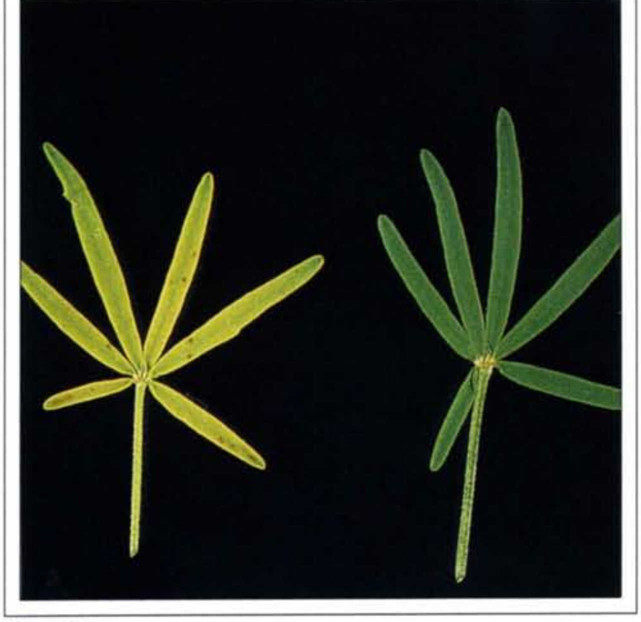


Plate 27

Iron deficiency in narrow leafed lupins. Early symptoms on the left. The leaf on the right has adequate iron.

Plate 28

Iron deficiency in chickpeas.

Plate 29

Severe iron deficiency in peas.

Boron toxicity

Plate 4:A
Boron toxicity symptoms in Chickpeas.

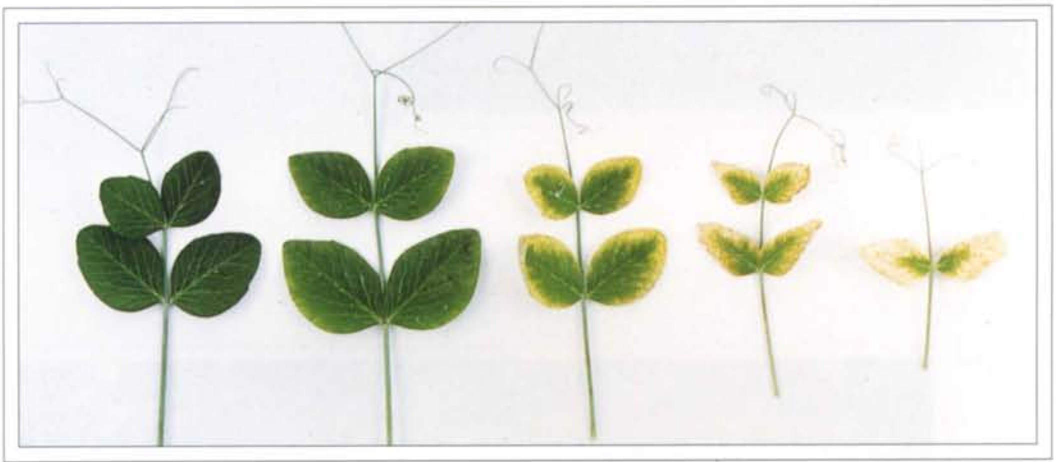


Plate 4:B
Boron toxicity symptoms in Peas.

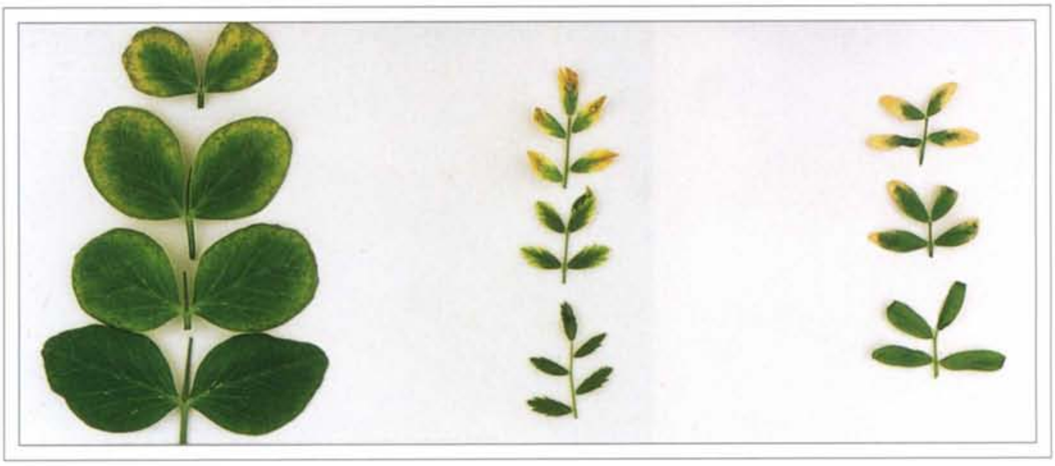


Plate 4:C
Boron toxicity symptoms.

Sulphur

Plate 4:D
Sulphur deficiency in Lupins.

Plate 4:E
Sulphur deficiency in Lupins.