SOME NOTES ON THE DIFFICULTY OF ESTABLISHING NURSERIES AND PLANTATIONS IN WESTERN AUSTRALIA.

By A.C. Shedley B.E.

Sir John Stirling-Maxwell has said,- "In Forestry, and especially in the afforestation of new ground, thefailures are the real extravagance". Failures or partial failures have been experienced in Nurseries and plantations in South Australia, N.S.W. and W.A. and there is ample evidence in Toumey to show that results of initial work in America have been anything but successful.

Greeley. (Toumey p.76) says "The experience of the past ten years on the National Forests, clearly shows that it would have been preferable to develop successful methods and learn their limitations on the most successful sites before attacking lands where forests were never produced by nature." In this paper, the difficulty of establishing new nurseries and plantations in this State is discussed, and a possible reason is suggested. Investigations have only been carried out in connection with the establishment of pines, especially Pinus insignis and Pinus pinaster on soils considered suitable for the particular species used and no attempt is made to deal with the failure of pines on unsuitable soils.

I propose first to deal with nurseries.

NURSERIES.- It has been found that in old established nurseries especially in South Australia, where planting has been carried out more extensively and over longer periods than in any other State, suitable planting stock of P. insignis is raised in 12 months or under, whereas in this State and N.S.W., attempts to raise good even stock of P. insignis in newly established nurseries in that time, have been unsuccessful. Even in South Australia poor results have been obtained on new nurseries, generally where these have been established at some distance from plantations.

In nearly every new nursery throughout Australia, there have always been patches, varying in size, carrying pines which were healthier and showed far better development than the remainder. The belief was held that the patches of good pines

were always associated with old stump holes or old burns, as evidenced by the presence of charcoal, and the knowledge that logs or stumps had been burnt; or in other words, the extra cultivation and additional potash assisted in the development.

The poor pines were stunted, being only an inch or two in height, yellow in color, not reaching beyond the primary needle stage and showed very poor root development during the first year. The same thing is seen with P.pinaster except that the needles turn a reddish colour.

It is interesting to note that the stunting of the pines appears after an apparently definite period from sowing and plants from Spring sowing show discoloration later in the year than do autumn sown plants.

During the second year, these pines, whether transplanted or left in the seed bed, in nearly every instance develop very rapidly, and when required for planting have often attained to a height of 3', thus increasing planting costs. A noteworthy development of the root system of such 2 year seedling plants, is their penetration to great depths and when the plants are lifted the only roots attached are 2 or 3 strong laterals with no fibrous roots or root hairs.

Various reasons have been suggested for the failure, among which are:-

1. Cultivation,- Lack of previous,
2. Manures, - Lack of Mineral Salts.
3. Moisture, - Insufficient supply,
4. Heat.

1. PREVIOUS CULTIVATION OF SITE.- In this connection 5 classes of sites have been tried, viz.-

a. Country cleared and cropped many years previously and in the interim allowed to run to grass.

b. Virgin land, cleared immediately prior to sowing of seed.

c. Virgin land, cleared 12 months earlier and cropped with field peas in the season before sowing with pine ~~pure~~ seed.

d. Land cropped continuously with field crops of various descriptions immediately prior to the sowing of pine ~~pure~~ seed.

e. Areas previously sown with pine seed.

With regard to a. 1st sowing has always proved a failure. - Greystone, Bickley, Collie, Byfields, Head Quarters, Mundaring Weir, Harvey Weir.

b. 1st sowing ditto.

South Perth, Weir Wall, Mungallup.

Somewhat contradictory results were obtained at Weir Wall Nursery on the South side of road, which however, was cultivated well during the summer prior to sowing.

c. 1st sowing a comparative success, but influenced by abnormally good season. e.g. Weir Wall Extension. and nearness to older nursery may have been responsible for good development of pines.

d. Comparatively successful, but still ~~unsuccessful~~ unsatisfactory. - Applecross and Gnangara.

e. - Will be referred to later.

This factor may prove to be of importance, but up to the present time sufficient observations have not been made to allow of any definite conclusion being arrived at.

2. MANURES.- Several beds in different nurseries have been manured with a number of the common manures. No benefit has been noticed from applying manures at the time of sowing or after the seed has germinated and there has been no difference between growth in control beds and in those manured.

The application of manure (espec. Superphosphate) at the time of sowing is to be discouraged on A/c of the strong weed growth induced. It has been noticed that, by applying, manure in the seed drills at the time of sowing a much greater development of weeds has taken place in the drills than between the rows.

The cost of weeding has proved the greatest cost in nursery practice.

3. MOISTURE.- It was thought that owing to the long dry summer experienced in W. A. and the absence of a retentive subsoil on areas available for Nursery sites, the plants were not able to get sufficient moisture for good development.

Overhead watering by spindlers and irrigation by channels in two nurseries in two successive years, was tried, but this failed to prevent stunting.

Control beds showed that watering aided the development of those patches which did not become stunted.

- Weir Wall and Head Quarters Nurseries at Mundaring Weir.

4. HEAT.- P. insignis and pinaster, have been grown successfully throughout Australia without shade. Knowing of the results obtained by shading in U.S.A. and N.S.W. experiments were carried out in this State to determine whether shading would prevent the stunting apparent in new nurseries. Definite beneficial results were obtained by the writer by shading Douglas Fir grown at Bago S. F. on the Southern Tablelands in N. S. W., where the summer shade temperature rarely exceeded 90° F.

Shading by means of brush, hessian and wooden slats was tried at the Nurseries in W.A. and has resulted in somewhat better root development and more even growth. In one case, good plants were rdsed from the first sowing. Pines, in the same bed, subjected to full sunlight became stunted and yellow in color.

Toumey and Neethling in "Some effects of cover over Coniferous seedbeds in Southern New England", scouts the idea of death of seedlings as being due to lack of moisture, but considers that most deaths were closely related to weather conditions. At times soil surface temperatures exceeded 122° - 130° F. and during these periods, deaths occured in the open beds and lesions at ground level were found on most of the species being grown.

The percentage of loss after germination with P. insignis in the shaded bed was - 5.1

Unshaded - 7.6

Mulched 11.6

With P. pinaster,

Shade - .67

Unshaded - 15.2

Mulched - 5.2

They further state, "Although ultra-maximal temperatures, beyond which death of succulent tissue ensues, vary between considerable limits, depending upon the species, the stage of development, and external conditions, a temperature of from 122°F to 131°F is recognised by authorities as fatal for most growing plants."

I am satisfied, however, that shading does not produce those sturdy woody plants so necessary for good planting results. Moreover a good deal of skill and attention is required in controlling the shades which should be removed on dull days and at night and gradually removed in the autumn so that plants become accustomed to full sunlight and are hardened off.

Shading may be necessary for certain conifers, The shading experiments carried out this year were of little value because of the early rains assisting in the development of the pines which all did well. Nurseries on many different kinds of soils and under varying climatic conditions in W.A. and N.S.W. have been established; but poor results have always attended the 1st sowing of P. pinaster and especially P. insignis. It is peculiar that good results both with P. insignis and P. pinaster have been obtained from late summer sowings (March), and these plants did not at any stage exhibit the characteristic discoloration.

Obviously early sowings can be undertaken only on ground which is damp all the year round or where artificial watering can be resorted to, to aid germination. Frosts do not affect us in W. A. and are of little consideration when dealing with autumn sowings.

It appears that the plants become established before the cold weather sets in and then are able to take advantage of the normal growing period which usually commences about the end of July. But the reason for the success of these plants is obscure.

It is thought that the good growth of seedlings on ash beds may be due to the presence of Potash, the better cultivation and physical cultivation resulting from the burn, the extra warmth absorbed by the dark soil and the production of nitrates usually associated with burns.

Under these conditions the pines develop rapidly and pass the critical period in their lives before the approach of summer.

The use of shades, artificial watering, the application of the common manures, and the cultivation beforehand of the soil, while undoubtedly affecting the growth of seedling pines, become of no importance when it is remembered that pines are grown successfully in old established nurseries without shading, watering, or the application of manures.

It is unfortunate that in this State, until last year successive crops of pines have not been grown in nurseries except at Hamel and at Ludlow. At the latter place the 3rd and 4th sowings on the same ground produced plants showing even growth without stunting.

An account of the history of the Greystone nursery at Mundaring Weir may be of interest here.

"Situated in a gully, close to the bank of a creek in which water flows all the year. This water becomes brackish to salty in summer.

The soil was the typical dark to black loamy sand of the locality, with a slight admixture of gravel on the higher levels. Moist soil was met with at a depth of eighteen inches or two feet before cultivation, at the end of summer on the higher slopes. Near the creek the soil on the surface is moist at this period of summer.

Germination was in all cases good, and progress satisfactory, until the beginning of November, when good development continued in little patches; the remaining plants developed a yellow tinge and stagnating at the same size all through summer. In autumn a slight improvement became evident, but in general the seedlings whose development was checked in early summer were unfit for planting in the intended season. In the following year the stunted yellowish seedlings in all cases made rapid development, and in two years from sowing attained a height of 18 inches to two feet."

Date of sowing.	Species.	Amount sown.	Results.
May-June. 1921.	P.insignis	12 lbs.	46,000 planted in 1922; but half of them were very small "runts" and unfit for planting making the cost of refilling high in 1923. Most of the remainder were lined out in 1922, making 12,000 transplants available in 1923.
June 1921.	P.pinaster	18 lbs.	14,500 were fit for planting in 1922, but the whole 29,000 were lined out in nursery rows and planted in 1923.
Spring 1921.	P.insignis	14 lbs.	Sown in the so-called "Spring" nursery. 4,000 were fit for planting in 1922. The remainder were reported killed by heat, dryness and salt. These seedlings, however, recovered and in 1923 16,000 2 year seedlings were available and were used for filling blanks in 1923 planting.
May. 1922.	P.insignis	14 lbs.	13,000 planted in 1923. The remainder were left in the Nursery and were used for refilling.

No seed was sown in 1923.

The majority of the area was left uncultivated and allowed to grow a dense crop of weeds in 1924. In this year a small bed was sown with seed of P. insignis and an even growth of very fair pines, rather spindly, resulted.

In 1925 a fairly large area of the land which had been previously under pines and left idle for a year or more was ploughed up and sown with Pine seed. This year sturdy one year old pines were obtained, better than 1 year old plants grown previously at Mundaring Weir. Moreover, on lifting of pines; it was noticed that the roots were whitish in appearance; and on closer examination it was found that a fungus was associated with the roots.

Mr. Carne, Govt. Botanist, after examination of the roots said.-

a. "The small roots are covered with a network of ecto trophic mycorhiza."

b. "The fungus is Rhizopogon luteolus."

At the Greystones nursery and also at Weir Wall, innumerable fructifications of Rhizopogon luteolus (identified by Mr. Carne) have been found this year. It is surmised that the Hyphae, which are everywhere threaded through the soil, are those of this fungus, but this fact is not definitely established. Mycorhiza was first thought of in connection with nurseries when it was discovered that the nodules usually found on the roots of legumes, were either missing or not well developed on poorly grown pea plants sown in the Headquarter's nursery for Green manuring.

Mr. Campion in his report of 20/10/25 states,-

" I have traced no reference to nitrogen nodules occurring among pines, but a species of Podocarpus having a mycorhiza is recorded by Strasburger as being able to utilise atmospheric N ..... It seems reasonable, therefore, to consider the nodules on Pines to have similar physiological significance, especially in view of the apparent failing of the pea crop along similar lines."

Further investigation of plants in nurseries sown for the first time discloses the interesting fact that the fungus is always in association with the well developed pines, but has not so far been found on the stunted pines.

This is illustrated at,-

Nanmup, Donnybrook, Gnangara, etc.

Moderately good pines have been found without the peculiar modification of rootlets. This formation which is such a feature of the pines raised in Greystones, was not noticed on the seedlings here until this year, when attention was drawn to it by the white appearance of the roots.

It is probable that odd pines have had it in past years.

It appears, therefore, that the pines do well when associated with the fungus and vice versa, and it is my opinion that the presence of the fungus is of vital importance not only in our nursery but in the afforestation of new areas whether by direct seeding or planting.

The following illustrations serve to support this view.

GNANGARA.- See notes. under

MUNDARING.- " "

COLLIE.- " "

LUDLOW.- " "

DONNYBROOK.- " "

GNANGARA.- Typical Coastal sand plain country.

Operations were commenced in 1918 and experiments carried out over a period of 6 years with broadcast sowings and plantings of P. pinaster on areas cultivated in various ways. Broadcast sowings have all been failures and hardly a pine survives except where growing under the shade of coppice growth resulting from the ring-barking of the larger Euc. trees.

Small areas were planted in 1918 and 1919 with P. pinaster sent from Hamel (An old established nursery)

1918 Plot suffered from a long dry spell after planting and has since been burnt.

1919 Plot - Plants are now healthy and growing vigorously the tallest being about 20 ft. high. (Fructifications are present).

In 1921 the planting stock came from Hamel and some of the plants had been lifted a week before they were finally set in the ground. The method employed was spearing or notching, seedlings being planted at the rate of 1500 plants per day. by 2 men

The best area is that planted first, while the others are only fair.

Considering the poor planting methods and the delay in transit, it is remarkable that any pines survived on this class of country.

The planting stock used in 1923 was raised at Ludlow and it was of very poor quality. Transplants from this Nursery, which had only been in existence for a year or two, were used.

A heavy mortality followed planting and generally the plants are poor and stunted, having made hardly any growth at all.

MUNDARING.- Generally speaking the refilling of the area planted with local stock has been a costly undertaking vide, Mudros and Greystones.

The 1922 plantation furnishes a good example of the difference between locally grown and Hamel Stock.

The best of the plants grown in the Greystones Nursery, which was first sown in 1921, were planted out first and then the smaller ones used on the adjoining area (June and July). Later in the season (Aug. & Sept.) a number of plants were forwarded from Hamel and planted on somewhat similar country.

The best pines now are those from Hamel Stock; next are those from the best local pines and lastly, those from the small local pines ("runts").

It seems significant that a heavy refilling had to be undertaken on the area planted with the smaller local pines and that the Hamel plants, in spite of the late planting and the transportation, developed so very much better than the remainder.

COLLIE.- The Sowings, whether in spots or broadcast have all been failures. A few pines, however, seem to be making fair headway on old burns. Nearly all the planting stock required for the different plantations at Collie were obtained from the local nursery and the growth of the planted pines (P.pinaster) is

anything but good. Slightly better growth is seen on old burns.

The records show that no area of nursery has been cropped twice with pines except during last year and it cannot yet be determined how the pines from the 1924 sowings, planted this season, will develop in the field.

In 1924, 200 P. pinaster plants were received from Hamel and these according to the Local Forester are making better progress than anything else.

LUDLOW.- Broadcast and drill sowings on areas planted 6 - 10 years previously with P. insignis from Hamel have been entirely successful.

On the other hand the records in the Ludlow Working Plan show:-

Compt. 10. Southern portion.

1919	1st planting 4' x 4' with P. pinaster(failure)
1920	Small area spot sown - failure.
1922	30 acres drilled with P. palustrus - failure.
1923	Drilled with P. pinaster - results satisfactory.

There are plants on this area remaining from the original planting in 1919.

Northern portion.

1919	Planted 4' x 4' with P. pinaster - failure.
1923.	Sown with P. pinaster.
1924.	Resown " "

From planting - these are individual healthy trees.

From sowing - the results are poor.

Compt. 11.

1919	Planted 4' x 4' with P. pinaster - failure.
1922	Sown with P. pinaster.
1924	Resown " "

Results very disappointing.

DONNYBROOK.- The spot sowing of a small area of the Arboretum at Donnybrook with P. canariensis resulted in good germination, but uneven growth. The Yellow Pines show no sign of the peculiar white modified rootlets and few or no threads of hyphae through the surrounding soil.

To Summarise:-

All the planting stock distributed from the Hamel Nursery, not only on the areas mentioned, but also in the different arboretums, are doing well, white very poor results have attended the use of stock from new nurseries.

It is interesting to read what Toumey has to say on the results experienced in endeavours to establish forests on new areas.

TOUMEY'S QUOTATION.-

"The experience of the past ten years on the National Forests, clearly shows that it would have been preferable to develop successful methods and learn their limitation on the most favorable sites, before attacking lands where forests were never produced by nature."

"Seeding and planting in the U. S. have been confined chiefly to the forestation of non-timbered areas, such as idle farm lands, extensive burns, natural grass lands and other sites where there was no possibility of reproduction from natural seeding."

"It is interesting to note that during the past decade, direct seeding on unprepared soil has been extensively practiced in the U.S., much less seed per acre being sown, however, than in Europe. The results have been equally disastrous."

"Full seeding has been practiced only to a limited extent in the U.S. and with but few species. For the most part it has been by broadcasting coniferous species on uncultivated sites.

Poor results have been due to four primary causes:-

a. The use of insufficient seed.

b. The destruction of seed by rodents.

c. Poor germination due to adverse seed beds.

d. The death of the seedling from summer draught."

"Successful regeneration from seeding in spots depends upon the species, the site, and the thoroughness with which the soil is prepared. It is usually most successful under an open overwood, where the soil is comparatively free from surface vegetation and on recently lumbered areas."

"Greeley emphasizes the fact that advantage must be taken of every feature of the site that may afford protection to the yound seedlings in locating the individual spots. Placing the spot on the North or East side of a stump, stone or mound of each, may afford the seedlings sufficient protection to bring them through the first summer, which is by far the most critical period in determining the success or failure in the regeneration after germination has been attained."

I now propose to give a short account of what information I have been able to gather from different sources concerning mycorhiza and its occurrence.

M Y C O R H I Z A.

The term mycorhiza is applied to the symbiotic combination of the filaments of certain fungi, whose complete development is as yet unknown, with the finest rootlets of certain plants.

The term was first given in 1885 by the German Pathologist Frank who brought under notice the biological importance of this combination of fungoid hyphae and root hairs.

Gr. Myco - mushroom Riza - root

Bower says that Fungi have the power of readily absorbing soluble salts from the soil and in accordance with their usually saprophytic life are able to obtain organic material in a combined form.

Mycorhiza can be divided into two main forms viz.-

Endotrophic (Intra cellular)
Ectotrophic (External)

1. Endotrophic - characteristic of Heath plants and of orchids. Fungal filaments are able to penetrate the cell walls of the host plant and pass readily from cell to cell. They are usually massed in certain zones, especially in the cortex and are coiled within the cell, the protoplast and nucleus of which still retain their vitality - indicating a symbiotic condition.

In the common heather the hyphae penetrate the stem and leaves also, and without the fungus, seedlings do not develop roots, although they may remain alive for months. With orchids certain cells are able to digest the fungus and so serve as a barrier, limiting the area infected by the fungus, while some orchids which are wholly dependent on mycorhiza, act as complete saprophytes.

2. Ectotrophic.- external. The fungus lives outside the tissues of the plant with which it is related. This form with which we are mostly concerned occurs with Beech, Hornbeam, Oak, and Pines.

The infected roots are short and thick and repeatedly branched, and appear clothed with a fungal covering.

Microscopic sections show roots covered by a thick felt of matted fungal threads, resembling tissue, which sometimes stop short of the tip, but usually covers it completely as in Pinus, Fagus etc. Sometimes nodules are formed about the size of a pea.

The fungal investment, however does not necessarily cover the whole root system. It replaces root hairs in young plants, but this does not mean that root hairs may not be present on the same root system.

Relation between Host and Fungus.

On thispoint there is considerable difference of opinion. Experimental cultures have given contradictory results as to benefits derived by the higher plants. Generally it is thought, however, that in ectotrophic, the fungal hyphae replace rootlets structually and functionally being provided with carbohydrates in return for water and minerals (i.e. symbiosis). One essential fact remains - namely, that this relationship is not a necessary condition of the life of the higher plant except under abnormal circumstances ~~e.g.~~. Scots Pine and Spruce grown on soils where nitrate supply is not obtainable are dependent either on organic N or ~~a~~ free N of the atmosphere. It is believed that in these soils mycorhiza has the power of absorbing incompletely decomposed Organic N., while in other cases it fixes free N. from the atmosphere. The relation is obligate for the host plant and absolutely necessary for the plants well being e.g. Scots pine on peat bogs.

It may be conjectured that the result of the partnership is to extend the range of the plant.

Where conditions are such as to produce toxicity affecting nutrition adversely, with consequent lowering in the resistance of plant cells, the normal relations between the plant and fungus are completely overthrown. Here the relation has ceased to be one of symbiosis and becomes one of parasite and host.

It seems clear that, - (Bower)

1. The fungus which is leading a saprophytic existence in the soil derives a direct supply of carbohydrate by contact with the root.

2. A more ready supply of salts and of combined N. is extracted from the soil by the fungus and there is abundant evidence to show that the fungus more able to absorb these, passes then on to the tree.

3. Hyphae establish a more intimate relation with the soil than do the ordinary root hairs.

It is probable that the relation is mutually beneficial because of,

a. Its prevalence,

b. The vitality which both parties show.

Its importance varies for different plants under different soil conditions e. g.

Beech on good loam - few mycorhiza and root hairs normal.
" " sandy acid soil - Increase in mycorhiza.
" " Heaths. - All root hairs replaced by mycorhiza.

It appears that both types of mycorhiza culminate in complete saprophytism at secondhand, generally the host plant is capable of nutrition in the ordinary way when growing in media in which nutrient salts are abundant, but becomes mycotrophic when the soils and situations are unfavorable to the production of directly absorbable food. e.g. on

a. Heaths and moors - soil almost wholly humus.

b. Beneath shade of trees where nitrates are rarely found.

RESEARCHES BY STAHL.- have shown that the symbiosis of mycorhiza instead of being a phenomenon restricted to a few species is widely diffused among many classes of plants and is indeed causally connected with other facts of wide general importance in plant nutrition. Stahl has shown that,

1. Plants with small transpiration current are furnished with mycorhiza. In this way they obtain food of all kinds from the soil. e. g., some conifers and heath plants.

2. Plants which give off water freely are never associated with mycorhiza.

3. Mycotrophic plants with a feeble transpiration current do not store starch in their leaves but soluble carbohydrates chiefly glucose. Normal plants first maufacture sugar which is rapidly converted into starch. With the accumulation of sugar in cells, concentration of cell sap is increased and hence it parts with its water by transpiration less readily.

4. The average proportion of ash to dry matter in the leaf is lower for mycotrophic than for normal plants.

Conclusion by Stahl is that symbrosis of myco. is very general especially characteristic of plants growing in soils.

a. Subject to draught,
b. Poor in mineral salts.
c. Rich in humus.

and these mycotrophic plants are,

a. Generally of slow growth,
b. Possess feeble transpiration,
c. Limited root development.
d. Leaves rarely contain starch,
e. Contain comparatively small proportion of mineral salts, among which calcium oxalate and nitrates are notably absent.

Hall in dealing with the flora growing naturally on sandy soils says, "Plants with myco. are abundant, owing, as already explained, to the comparative poverty of these soils in both water and soluble salts."

SYSTEMATIC POSITION.

There may be 1 fungus to many host plants or 1 host to many fungi.

OCCURENCE IN THIS STATE.

So far in this state the only fungus suspected of symbrotic relationship is that identified by Mr. Carne as Phizo-
pogon

luteolus belonging to the family Hymenogastroaceae and has been found associated with P. insignis and P. pinaster. Mr. Carne states that it has been noted by Butler and others that where symbiosis is well developed the fungus may never or rarely fruit. The spores are mature when the fungus body becomes soft and are discharged in a liquid mass, when the fungus body collapses and ruptures. It is interesting to note that Rodway says Phizopogon rufescens is symbiotically associated with pines in Tasmania.

The fructifications are numerous this year and have been found in close proximity to the following pines.

P. insignis	P. halepensis
P. pinaster	P. canariensis
P. pinea	P. taeda

It is evident that the fungus is connected with the young roots, for the taller the tree the further are the fruiting bodies from it. On the Donnybrook-Boggerup road, the majority of these fructifications were found at a distance of nearly 100 feet from the trunk of the trees.

The remarks on mycorhiza

~~This~~ leads us to the question of Nitrogen supplies and the following quotations and extracts which apply to European conditions, may be of importance in Australia.

① In dealing with the presence of Nitrates in the soil it is said that its formation is influenced by,

1. Shade - better in the open generally,
2. Presence of brushwood and decaying timber. Better results are obtained near decaying stumps.
3. Preparation of the ground - aeration and earthworms assist.
4. Burning. In our soils, nitrate was not present but after burning it was. Hesslenian said that it was not due to the presence of the ash which washed out in the 1st year as the effect is felt over a number of years. Burning induces nitrefication in the soil.

On the above factors depend the various methods of treatment for regeneration. There is a close parallel between the nitrefication of humus and the regenerative possibilities of the ground. Forests where selection cuttings produce nitrates are comparatively easily regenerated.

The way in which we affect transformation of humus N_2 ought to be the leading idea in measures of forest regeneration.

② Researches have been carried out by the Danish Forest Research Station with the cultivation of Picea excelsa on heaths because of the stagnation, from 5-30 years which this tree usually exhibits on poor soils. The height growth is reduced, needles short yellow in color, showing Nitrogen hunger, and lack of assimilative nitrates in the soil.

Experiments were started in 1903 by manuring with Lime, Potash and Phosphate, but there was no improvement in development. Certain nitrate manures however were effective.

It was seen that no stagnation occurred when,

1. The soil had been cultivated several years prior to planting, thus encouraging the development of nitrate binding bacteria.
2. When soil enriched with N. by the cultivation of lupines.

3. Interplanting with P. montana.

The effect of P. montana was slower than the legumes, but the effect was more lasting. P. montana carries both endo and ectotrophic mycorhiza.

Further experiments with regard to nursery stock were carried out with P. montan and Picea excelsa 2 beds of each.

One bed of each species was manured with Chile nitrate.

1st year at rate of 55 kilograms per hectare.

2nd year twice this quantity distributed four times at 1 months interval at the conclusion of the second year, plants from manured and unmanured plots were cut off at ground level and weighed with the following results.

	P. Montana		Picea excelsa.	
	Manure	Unmanured.	Manure	Unmanured.
Kilos per 100 plants.	27.3	33.2	34.6	19.4 / These were yellow with short needles.

It is now the recognised practice that Picea excelsa in ~~Western Norway~~, Jutland ~~and N. W. Germany~~ on poor heaths are all established by interplanting with Pinus montana which brings the Spruce over the stagnation period.

It is evident from the foregoing remarks that Nitrogen supplies are obtained by different plants in different forms, as a Leguminosae from free N. of atmosphere, and again in the combined form as nitrates and organic Nitrogen; and also through different agencies.

It is thought that with P. insignis and P. pinaster in this State, the fungus associated with these species renders ample supplies of N. available and that those plants showing characteristic discolored and stunted appearance are suffering from N. hunger.

The subject matter of this paper is merely a collection of all the available information which may relate to this complex problem connected with the failure of new nurseries and plantations.

The paper has been read in order to promote discussion and in the hope that it may induce further investigation into the matter.