# OBSERVATIONS
# of
# A LILY BREEDER

## by Charles Robinson


Ontario Regional Lily Society
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THIS BOOKLET CONTAINS

REPRINTS OF

CHARLES ROBINSONS ARTICLES

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ONTARIO REGIONAL LILY SOCIETY

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FORWORD

Charles (Robbie) Robinson is indeed a rose among thorns, or perhaps better expressed as a 'Lily' among thorns. Robbie's enthusiasm for lilies cannot be simply described. I am sure anyone who has walked through his lily gardens with the master himself, or has read his articles on lily culture will soon realize that here is a man truly versed in the genus lilium.

In 1970 Charles Robinson entered a new unnamed lily seedling, a cross between Lilium candidum salonikae x L. monadelphum, in the International Show of the North American Lily Society in Hamilton, Ontario. Few of us were acquainted with this obviously keen hybridizer at the time but lily sages knew that what he had created was a breakthrough in lily breeding. We have since come to admire this wise, knowledgeable and always sharing gardener, who through the medium of our Newsletter has provided a wealth of information to lily growers everywhere. His writings not only reflect an in-depth knowledge of lilies but also his love for them.

Charles Robinson was born in Lancashire, England in 1908. At the age of 18 he entered the trial grounds and plant breeding establishment of Thos. Clucas and Sons in Armskirk. After attending the Lancashire Agricultural College, John Innes Horticultural Research Institute in Surrey, and the Royal Botanic Gardens at Kew, he entered the British Ministry of Agriculture as a field officer, serving in England and Kenya. Charles served in the Royal Air Force for a period of five years.

In 1946 Charles Robinson emigrated to Canada and became editor of agriculture and horticulture publications for Monetary Times, later bought by the Southam Company. Robbie retired in 1965 and has spent his retirement years with his wife, Jean, in the Caledon Hills area of Ontario.

Robbie's interest in lilies goes back many years but it was June Fragrance, the name given to the L. candidum salonikae x monadelphum cross that spurred his enthusiasm even further. His breeding with L. amabile, L. callosum, L. cernuum and more recently L. pumilum has resulted in new vigorous hybrids. New spotless seedlings have become a trademark of his work at recent Ontario Regional Lily Society shows. And yet, with all the skills to create these new children of the genus, he is willing to share his observations and knowledge with all of us. This booklet reprints four of his contributions to the Ontario Regional Lily Society Newsletter. We are proud to have Robbie a vital part of our Society and to be able to share his knowledge with other lily growers everywhere.

T. Ross Martin,
Editor

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# PART I

# AN INTRODUCTION TO LILY HYBRIDIZING

Let me begin by saying that hybridization involves the crossing of closely related plants in order to bring together in the hybrid all of the most desirable characters possessed by both parents. Furthermore, new combinations are readily produced by crossing. Probably the most important task which faces every breeder is the selection of the parents. Where this has been carried out with care the progeny may offer one or more superior seedlings which are a definite improvement over their parents. Conversely, where parental selections has been at random and without much thought the results will invariably be disappointing. The thought, then, is that only the finest varieties available should be used. Anyone can begin at the bottom and work upward, but the discerning breeder or prospective breeder will start with the best and go higher. One observation I have made over the years is that those bulbs needed for seed production the following year should be in the ground as early as possible, preferably the end of September. Such bulbs may only yield a half crop of seeds. Furthermore, (and I have no statistics or such to prove this) November planted bulbs have difficulty in producing any seeds at all. This is due, I think, to the lack of association between roots and soil -- almost the same as being overwintered in the refrigerator and planted out early in the spring. September planted bulbs, on the other hand, have ample time to make a good root system before freeze-up and get a good start the following sprin

Although techniques may vary from breeder to breeder I will describe what I believe every prospective breeder should know about the mechanics of crossing two lilies. Put in a very simple way, a lily flower consists of six tepals (3 petals and 3 sepals), six anthers which are the male reproductive organs and contain the pollen, together with the pistil, which is the female organ made up of the stigma, style, ovary or capsule, and the ovules; the latter, when fertilized forms the seed. The object of the breeder, then, is to take the pollen from one parent and place it on the stigma of the other parent. Other things being equal, seeds containing hybrid embryos will result.

In order to pollinate successfully and ensure that the resulting seeds are of the desired parentage, a certain technique is needed. First, the flowers should be opened at lease 24 hours before each one would open naturally, and the anthers removed. Keep the anthers from the parents seperate, of course, and carefully dry them until they split longitudinally, exposing the pollen. By this time the first of the flowers should be about ready for pollination. Take the pollen from variety A, and with the aid of a child's camel-hair brush, pipe cleaner, paper spill or other such aid, put the pollen on the stigma of variety B. Then reverse the process by putting the pollen of variety B on the stigma of variety A. This is known as reciprocal crossing and should always be resorted to where the seed-producing capacity of both parents is not known. As an example, in some cases A will yield seeds where pollen from B is used, but B will not produce seeds when pollen from A is used. So make sure to pollinate both ways where possible. In time, experience will dictate which varieties will produce good seeds, and which will not. This also applies to pollen production, some varieties produce no pollen at all, or the pollen is sterile. Careful observation is of great assistance.

How many flowers per plant should be pollinated. This, of course, largely depends on the amount of seed required, and how much garden space can be allotted to the growing of the seedlings. On a per plant basis I never pollinate more than six or seven flowers and after fertilization is effected I reduce the number of capsules to about four. This ensures that the seed parent is not overtaxed. Always use the lower flowers for pollinating, they always produce more and better seeds than the upper ones. Incidentally, if the stigma is receptive (usually 24 to 36 hours after natural opening) and pollination is carried out, fertilization of the ovules will normally result in about 36 to 48 hours. After opening, flowers are usually receptive to pollen for about seven days.

Pollen storage is a subject that should be fully understood.

It must be carefully dried and stored in a dry place unti ready for use. High humidity is always dangerous because under such conditions moulds readily attack and destroy the pollen. To avoid such conditions I always dry the po len and store it in an airtight container containing one or two tablespoons of calcium chloride, obtainable from a drug store. This chemical is deliquisant, absorbing an holding all moisture within the container. Thus, the air within is absolutely free of moisture and the pollen perfectly dry. This procedure need only be used where polle has to be kept for several weeks. It is not necessary fo short term pollinations of, say, less than two weeks between collecting and using the pollen. Occasionally it may be necessary to carry pollen through the following winter for use the next summer. In most cases this is easily done by using the above described techniques and placing the air tight container in a freezer or the freez ing compartment of a refrigerator. The pollen from the Orientals overwinters very well under such conditions and I have had no difficulty with the Asiatics. I have had no experience with the Western Americans and only poor results from trial tests with the Martagons. Admittedly, more information is needed about the latter.

But what happens when the pollen has been placed on the stigma? After a few days it will be noted that when fertilization has been effected the style begins to wither, the end of the pedicel assumes an upward position, while the capsule moves in a similar manner until both the pedicel apex and the capsule are in an erect position. Growth of the capsule then begins in earnest. This movement of pedicel and capsule does not take place in the up-facing group of lilies. But before fertilization takes place a rather complicated series of actions, impulses and responses take place. I'll try to describe them as simply as possible. First, the pollen adheres to the stigmatic fluid -- a sticky substance covering the stigma -- which not only provides an anchor for the polle but also provides it with nutrition as well as a hormone which gives impetus to the growth of the pollen tube.

Similar hormones also exist in the style and ovary, and for much the same purpose. Each plays a very essential part in successful fertilization. Such hormones are extractable and can be used in difficult-to-achieve crosses. But such methods are usually regarded as being beyond the reach of the amateur lily breeder. At this stage the pollen grain swells and germinates, forming a tube which grows down the style either by digesting some of the stylar cells or by growth down a stylar canal. The growth of this tube is controlled by a tube nucleus situated near the tip of the tube. There is also a second nucleus in the pollen tube containing the haploid or half number of chromosomes contributed by the pollen or male parent.

As the tube grows this nucleus divides into two, as do the chromosomes within. We now have two nuclei each containing 12 chromosomes. Within the ovary each ovule is attached to the placenta, from which it was formed, and each containing eight nuclei, but we will concern ourselves with the three most important ones -- one being the embryo or egg nucleus, the other two the polor or endosperm nuclei. When a pollen tube enters an ovule it discharges the two generative nuclei, one fusing with the two polar nuclei while the other fertilizes embryo nucleus and forms the embryo or new plant. The endosperm provides all the nutritional needs of the embryo until such a time as the seed, for seed it now is, germinates and is capable of providing for its own needs. In the meantime the pollen tube and tube nucleus disintegrate, their task completed.

We now deal with another important aspect of lily breeding, namely, self incompatibility or the failure of pollen to fertilize ovules on the same plant, in spite of the fact that such pollen may readily fertilize the ovules of a different variety. Lilies are best described as being self incompatible but cross-compatible. This is why we have always to use two dissimilar varieties in order to produce seeds. Self-incompatibility is nature's way of preventing inbreeding and a possible reduction in stamina and reproductive capacity.

In some cases, however, breeders who have produced an outstanding seedling feel it necessary to overcome this incompatibility in order to produce a strain of seedlings of superior quality, by fertilizing the ovules by pollen from the same plant or even flower. By using certain techniques self-compatibility can be achieved. The use of hormones has already been discussed. Then there is the hot water treatment which consists of immersing the style in hot water at a temperature of 112 degrees F. to 115 degrees F. for a period of from four to five minutes. To the best of my knowledge nobody has advanced any theory as to why such treatment should overcome self-incompatibility, although I suspect that this heat treatment changes the composition of a hormone known to be located within the style and which inhibits pollen tube growth, thus preventing the tube from penetrating and reaching the ovules. This particular hormone is one of the main reasons, if not the main reason, why pollen cannot effectively fertilize ovules on the same plant. Once this hormone has undergone a change, however slight, its inhibitive power is lost. I further suspect that the growing of lilies in a greenhouse facilitates the production of seeds from difficult-to-cross lilies, and for much the same reasons as the hot water treatment. The high temperatures in mid-summer in a greenhouse may cause the inhibiting hormone to undergo a chemical change and allow some of the ovules to be fertilized. At the present time we know little or nothing about these compounds which inhibit or stimulate pollen or ovule performance, although knowledge is slowly accumulating. Another 'trick' sometimes resorted to is the cut style method in which the style is shortened, leaving only about one-half inch adhering to the ovary. The cut should be made with a razor blade at an acute angle which leaves a large surface area exposed. As soon as the cut is made it will be seen that there is an immediate flush or flow of stylar sap. Remove this with a tissue and immediately put the pollen on the cut style surface. Don't wait, because the sap hardens quickly on exposure to the air, and this will prefent the entrance of the pollen.

One rule to follow is that where there is ample pollen, and there usually is, always crowd as much as possible on the stigma. Pollen contains a growth promoting hormone and it is a well-known fact that additional pollen provides additional auxins and there is greater impetus to pollen germination and growth.

I have already described the fertilization of the ovule by the pollen's two generative nuclei in which one fertilizes the embryo nucleus, the other fusing with the polar nuclei to form the endosperm. We cannot, of course, see these actions taking place, but we do see what has happened when we examine the seeds at harvest time. I classify seed into four groups ... (1) those which have neither embryo or endosperm and consist solely of a transparent seed coat, indicating that neither the embryo nor polar nuclei were fertilized; (2) seeds somewhat similar to the above but possessing an embryo, usually withered or dead. In this instance the embryo was fertilized but not the polar nuclei, hence, an embryo, indicating polar nuclei fusion only, and (4) the good, viable seeds having both embryo and endosperm. These latter, of course, are the only ones of value.

Breeders occasionally run into what can best be described as a phenomenon in which pollination takes place, the capsule swells and matures to what appears to be its maximum size and contains a full compliment of large seeds. Later it is found that not a single seed contains either embryo or endosperm. What has happened is that the pollen has penetrated the stigma and entered the stylar tissues. But here all growth ceases, although an impulse has been set up and a response occurs in which the ovary and ovules begin to swell and continue to grow despite the fact that fertilization has not taken place. Such happenings frequently occur in crosses which are botanically distant, such as Western American x Martagon, Henryi x Oriental, Asiatics x Henryi, as well as between types within the same lily group yet believed to be cross-incompatible. It is well within the bounds of possibility that plant breeders working within such groups may one day be rewarded for their persistence.

No discussion about hybridizing can possibly be complete without an examination of the very heart of the subject - the chromosomes and the genes. If a cell from the somatic or body tissues of a lily is subjected to mocroscopic examination, it will be seen that it contains a sperical body called the cell nucleus, and the largest identifyable bodies within this nucleus are the chromosomes. Lilies normally have 24 chromosomes although it is more accurate to say that they have 12 pairs, one of each pair being contributed by the pollen or male parent, the other of the pair coming from the seed or female parent. The number, size and shape of the chromosomes are the same in all the body cells of a lily, or for that matter any living organism and indeed with rare exceptions throughout a particullar species. Every lily plant grows by the process of cell division. Between successive divisions (the resting stage) the chromosomes are not easily seen, but when cell division is about to begin they can be seen as twining bodies which are split lengthwise. Finally, these half chromosomes thus formed begin to move toward the opposite ends of the cell, as if each of these half chromosomes were strongly repulsed. When the half chromosomes are at the poles of the cell they begin to again pass into the resting stage and a cell wall is formed between these daughter nuclei, each of which contains precisely the same number of chromosomes as the original parent cell. After a suitable length of time the process is again repeated. The chromosome itself is organized into units, several or many of which are carried in linear order along its length. Each of these units is known as a gene and genes determine the character of the lily. However, the hereditary connection between one generation and the next is by means of the chromosomes on which the genes are carried, and the transfer from one generation to the next is done by the sex cells -- the pollen and the ovules. When a lily begins to form it sex cells, a special type of cell division takes place, scientifically known as meiosis but more simply as the reduction division, in which only half the number of chromosomes, 12 instead of 12 pairs, pass into the sex cells.

This haploid, or half number, is very necessary in order that when a pollen grain fertilizes an ovule the resulting embryo will have a total of 24 chromosomes (12 pair) as in every normal lily plant. These paired chromosomes are alike in purebreeding individuals such as species, but may be slightly dissimilar in other lilies within a particular group. Just how similar or dissimilar they are determines the possiblity of crossing them. But not always; where a cross between plants (or animals) having dissimilar chromosomes has been achieved the offspring are usually sterile.

Let us assume that we have created a hybrid by the methods already discussed, just what part do the genes play in the development of the plant? It is generally believed that each gene has one major and perhaps several minor roles to play. Conversely, the expression of a character is usually dependent on the major influence of one gene with perhaps other genes playing minor roles. Generally, however, we merely recognize the major gene and ignore the others. Thus, will L. pumilum with its orange-red flowers we deal only with the two genes for red colour, stated R R, one from each parent. However, some colours or other characters may depend on more than one pair of major genes before they can express themselves. Now suppose we cross L. pumilum with its yellow variant, Yellow Bunting. The resulting seedlings will all be a shade or orange-red and there will be no yellows. Thus, the red of pumilum is said to be dominant to the yellow because it completely masks it.

Geneticists indicate dominance by using the capital R for the dominant red and a small r for the recessive yellow. The colour constitution of pumilum, therefore, would be R R (one R from each parent) and Yellow Bunting r r. The hybrid between the two would obviously have the constitution R r ... the R from pumilum and the r from Yellow Bunting. But why would any breeder want to cross pumilum with Yellow Bunting?

The answer, of course, is that he wishes to effect an improvement by combining the yellow colour of Yellow Bunting with the much stronger constitution of pumilum (such an attempt has been made many times). But the seedlings are all of an orange-red colour, something similar to pumilum but perhaps a little lighter. What now? As we have shown, each of these seedlings is carrying the colour genes R and r and if two such seedlings are intercrossed the Law of Segregation takes over. This law states that genes brought together in one generation will seperate when that generation reproduces and forms offspring. In this next generation will be found the plant or plants with the desired characters, and for which the cross was made. In the above example we have only dealt with a one character difference. When two or more characters are used, a much greater number of offspring will have to be raised in order to produce the plant with all the desired characters. The more characters we deal with, the greater will be the population needed for success.

We have so far dealt with genes which are either dominant or recessive. It should be said, however, that in the lily most of the visible characters are neither truly dominant or recessive. They are somewhere in between. Again using colour genes as an example, the state of dominance or recessiveness can be stated in percentages; thus 80% dominant and 20% recessive, 60% - 40%, 75% - 25%, and so on. This state is known as incomplete dominance. Another important fact about genes is that when we describe them as being dominant or recessive they are only so in their relation with other and particular genes. A gene which is dominant in one instance could well be recesive in another. Genes for lilac colour are dominant to white, yet recessive to red.

We will now move along and study gene expression, namely the character. To lily growers colour is an excellent example for study and observation, and a close look at the variety of colour characters will help us to understand something about inheritance.

The colours of asiatics (Division I of the recognized lily classification), can conveniently be divided into two groups - (1) the orange-red group, and (2) the lilac group. In group 1, and in descending order of dominance are orange-red, orange and apricot, bright yellow and pale yellow. Orange-red is the most dominant colour, bright yellow being the recessive, while pale yellow is the final recessive by virtue of the fact that it is recessive to the recessive bright yellow. But any grower who has hybridized within the group may have been perplexed by the appearance of dark reds among the seedlings. Dark red is something of a phenomenon because it is unknown in any of the species from which our present asiatics are derived. A genetic study shows us that dark red is controlled by two pairs of genes, one pair which we will call C C being carried by one parent, the other by the second parent. This latter pair we will call A A for the sake of simplicity. The C C colour genes, however, cannot produce colour by themselves, but only when A A are present. These latter are known as complementary genes and act as catalists for the C C genes. Not very much is known about the C C genes except that some plants within the L. Willmottiae - L. amabile complex carry them. Some within this complex also carry the A A genes, as do some lilacs. When these dark reds first appear the colour is modified by orange-red -- the parent colour, but intercrossing and selection can produce pure-breeding dark reds.

Another interesting feature is that when these dark reds are crossed with yellows the colour bronze appears, a colour not found in nature. The appearance of bronze seedlings has always interested me because of their variability; some are typically bronze with about equal dominance of the red and yellow; others have a bronze face and yellow reverse or a yellow face and bronze reverse, again equally dominant but possibly with pattern genes at work. Although dark red is known in nature it is restricted to the species L. papilliferum, whose natural habitat is extremely limited.

Authorities have theorized that the colour is such that pollinating insects are not attracted to it; also, lilies with dark red flowers are known to more susceptible to lily diseases. Group 2, the lilacs, are represented in nature by _L. wardii_, _L. lankongense_, and _L. cernuum_. All of our lilacs, or pinks as they are called, have been derived from cernuum and some of them carry the A A genes, and when crossed with the orange-red group we occasionally get the dark red, but this time modified by lilac. This colour is usually referred to as fuchsia and there are several named varieties which typify this colour. In this Group 2 are several sub-sections namely deep lilac, medium lilas, pale lilac, rose, pink, salmon, and white. I have placed them in the approximate order of descending dominance. I say "approximate" because these days it is often difficult to determine precisely to which group a colour belongs and thereby to what degree it is dominant or recessive. White, of course, is recessive to all colours, yet white asiatics can be further divided into at least four different genetic groupings, which illustrate just how complicated our lilies are becoming. But our study does not end here because there are now many colour combinations which have resulted from our breeding efforts. As examples, there are white modified by yellow, by pink (blush), by apricot (fawn), and also by red. This state can also be applied to most other colours within groups 1 and 2. Yet we have undoubtedly only begun to tap the resources of the asiatics. Surprises seem to occur each year in the seedling beds. To name a few; seedlings having flowers heavy with papillae (I always think that papillae adds tremendous character to _L. speciosum_ flowers) flowers having orange or orange-yellow surrounds to each spot, and another type in which the flowers can be described in two ways -- yellow with large orange centres or orange with broad yellow petal edges. Bicolors are also making an appearance to broaden the colour spectrum. It is the first sighting of one of these newer colours that makes lily breeding so fascinating. It is in this particular area that keen observation becomes most important.

So far we have only dealt with the colours of asiatic lilies. However, those colours found within the western American and martagon sections are quite similar to the asiatics, not only in general appearance but also in the molecular structure of the colour compounds. The interactions of the genes follow quite closely those I have mentioned in the asiatics. This similarity can readily be understood if we give some thought to the evolution of the lily. Starting with the Proto (or original) Lilium from which all our lilies have descended, the evolutionary tree shows that L. hansonii is considered to be the lowest branch, followed closely, but just a little higher, by the martagons. Much about the same time the Western American group emerged. Although differing from the martagons botanically the colours were passed on with only very slight modifications. On a much higher evolutionary branch is the asiatic group, significantly different botanically, yet having much the same colours and gene interactions as the martagons and Western Americans, but once again with slight modifications which have taken place over thousands of years. This being so, the information relating to asiatic colours can also be used by breeders working with the martagons and the Americans.

Apart from the normal genes which control colour there are still others that play an important part in the expression of lily colours and colour patterns. There are intensification genes which intensify colours, dilution genes which dilute, inhibiting genes which do exactly that, and collectively they are known as modifying genes because they do modify the basic colours. Another and very important group, is the pattern genes which dictate just where each particular colour will be laid down on the flower tepals, or what particular pattern the spotting will be. There are many spotting patterns in the asiatics, and other groups. To understand this, breeders should examine the differing patterns of such species as L. Lankongense, Monadelphum and Tigrinum, not only note the differences but also how a particular pattern persists throughout the species.

And so it is with the hybrids; each clone will have its particular colour and spotting patterns. All these characteristics are the direct results of the actions of pattern genes. Let's take a look at say, L. regale, a white lily with a broad reddish-purple band on the exterior of each tepal, and a yellow throat. Under normal circumstances this pattern persists and is under the control of the pattern genes. When a mutation or change occurs and the colour pattern varies from normal, it is due to the pattern genes having undergone a change from dominant to a recessive state and can no longer control or dictate where a particular colour will occur. Some years ago this did happen, and still happens occasionally, and the colour of the reddish-purple band seeped or spread onto the main body of the tepals; it also passed to the inside of the flower. Then by selection, breeders finally acquired what is now known as the pink trumpet. This is just one illustration of pattern gene actions in both the dominant and recessive states. You will note that I have used the word "mutation". It denotes that a change has taken place and a new character has arisen quite suddenly. Although gene mutation is fundamental to variation and evolution, change can also occur through alterations to chromosome structure and number.

Early in this book I made mention to the fact that lilies normally have 24 or 12 pair of chromosomes. These are known as diploids, meaning that they have two sets of chromosomes, one set or one of each pair being contributed by the male parent, the other of each pair, 12 in all, being handed down from the female parent. But abnormal types do occur either naturally or by man's design. Forms known as triploids (3 sets of 12 chromosomes) occur in the tigrinum group, notably varieties splendens and fortunei. There is a double-flowered form which I believe is also triploid. Such abnormalities originate through the failure of the cell to reduce the chromosome number from 24 to 12 at the reduction division at which the pollen or ovules are produced.

If such an unreduced cell becomes, say, a pollen grain with 24 chromosomes and fertilizes a ovule with 12, the total will be 36 instead of the normal 24, thus having three sets of 12 instead of two. Hence, the use of the word triploid -- tri meaning three. Triploids are usually infertile because of chromosome complications and have had little or no impact on the production of present day hybrids. For that matter, neither have the tetraploids (tetra meaning four) which have four sets of 12 chromosomes and which were produced by the use of the drug colchicine, derived from the colchicum or autumn crocus. There are a few tetraploid lilies around and they do produce good pollen and seeds, but only when crossed with other tetraploids. This group should contribute much more in the future.

One group which has played an important part in the development of the asiatic section is the Patterson lilies which were derived on the one hand from the species L. cernuum. These varieties can be further divided into two groups (1) the diploids with 2 sets of 12 chromosomes, and the (2) aneuploid group, the varieties of which have an irregular chromosome number abouve 24. These aneuploids obviously arose through the crossing of a diploid with a triploid and are highly infertile, seldom producing good pollen or seeds. But this infertility is not confined to the aneuploids; it is also present among the diploids. I assume that whatever the cause this state of infertility runs through both groups but is further complicated in the aneuploid varieties by the additional chromosomes. The inevitable irregularities which occur at germ cell formation (pollen and ovules) makes matters difficult for the lily breeder interested in the lilacs. However, many of the newer varieties derived from the normal hybrid - Edith Cecilia - are either fertile or reasonably so. Breeders should make use of these rather than the older Patterson varieties.

At the present stage of lily development I believe it is best for lily breeders to select parents by visual appraisal only and avoid inbreeding, line-breeding and back-crossing unless there is a very special reason for so doing This does assure a certain measure of heterosis or hybrid vigor which in turn will give us healthy and virile progeny. To simplify the task of designing a sound breeding program it is only necessary to use four colours --- Orange-red, apricot, yellow and pink. One bulb of each will suffice but make sure they are the finest varieties available. From these four colours every known colour in the asiatic group can be obtained. Be sure the lilac is free from any modifying colour as this will make the task much easier. Yet we find there are many others to which we will have to pay equal attention -- characters such as height, foliage, disease resistance, flower texture, etc. Breeders cannot afford to overlook any of them

Finally, may I say that I hope members will derive some little benefit from this book. For those who wish to keep their breeding efforts at a simple level just learn the art of crossing two lilies, as I have described, then go ahead and enjoy yourselves. Lily breeding is a very pleasurable hobby and can be so rewarding in many, many ways.

# PART II

# RANDOM THOUGHTS OF A LILY GROWER

I suppose we all give considerable thought about the techniques of growing and breeding lilies. Depending on individual interests -- whether growing superior specimens for the garden or for exhibition, or whether our main interest is the production of improved varieties, our minds are constantly searching for new methods or new ideas which will enable us to better accomplish our goals more readily -- or at best to find a method which may assist us to obtain results previously believed to be impossible. I am constantly on the search so I suppose every lily grower does likewise.

In order to write in a more different vein than usual I will give a few ideas that have occurred to me from time to time, my thoughts about such ideas, and what I have done about them. However, It should be clearly understood that they are, as yet, merely ideas which need verification and thorough testing before they can be regarded as having practical application. Any lily grower, of course, is quite free to use any of these ideas, give them testing, and perhaps make some contribution to the furthering of our knowledge about the subject in which we are all so keenly interested.

Growers who have propagated lilies from seeds, whether such seeds were collected from species or hybrids, must at some time or other have lost some of the crop through frost damage to unripe capsules or seeds. Green lily seeds and tissue are quite susceptible to frost damage. What happens is that the cell sap freezes and tiny particles of ice are formed which damage the cell contents and rupture the cell walls. On thawing, the cells collapse and ultimately degenerate to a dark, spongy mess which is typical of any plant tissues killed by frost. Occasionally, seeds and capsules do not deteriorate to a soggy, spongy mess but appear to have been destroyed by a process of freeze-drying. After the frost damage the capsules dry and appear to be reasonably normal. On opening, however, the seeds are considerably shrivelled and brittle; in size they appear to be about one-half or less than normal. The degeneration of both endosperm and embryo is apparent.

To avoid the possibility of frost damage growers will often cut the pod-bearing stems, take them indoors and place them in water - and hopefully keep them until the pods and seeds ripen. This method, however, in no way guarantees good seeds. Often attacks by fungi occur; damping off often occurs in unsuitable environments. Under ideal conditions this method is a good one, but anything other than good conditions will bring about a crop failure.

Last year I decided to try another method. Towards the end of September I selected a nice fat pod from a trumpet hybrid. Taking it indoors I opened it up by "skinning it" in much the same manner as one would skin an orange. After carefully removing the seeds they were placed on absorbant paper to remove the external moisture. The seeds were very green, fat with swollen endosperm and moisture. Later on, after comparing the pod to others on the same trumpet lily plant, I came to the conclusion that the pod I was dealing with was at least three weeks, but more likely a month away from normal ripening and opening. At this one-month-from-ripening stage, one point of interest was that within twenty-four hours these very green seeds showed slight traces of brownish coloration such as would be seen on seeds left to ripen on the plant. Forty-eight hours after removal from the pod there were very definite signs of browning; this browning or ripening increased with the passing of each day. This browning or ripening is possibly due to the oxidation of tissues when in contact with the air. Some of the seeds were so fat with endosperm and moisture the embryos could not be seen. However, in order to carry the test a step further I managed to isolate seventy-eight seeds which showed good embryo and endosperm development. These were sown in a pan, indoors, on October 1, 1976. On November 1, five seedlings were showing, and from then on germination was rapid. On New Year's Day 1977 all seedlings were removed from the pan and counted. There were 69 out of a possible 78, which is an 88.5% germination, good by any standard.

The above experiment might indicate that green seeds can be removed from the pod one month ahead of ripening and either sown immediately or carefully dried and retained until a more convenient sowing date. One further fact should be stated here: As the cotyledon appeared above the medium bearing the seed coats the latter appeared exactly the same as seeds which had been thoroughly ripened before sowing, which raises one question..... did the green seed ripen first and then proceed to germinate or did the ripening process and germination proceed together?

Further investigation will have to be undertaken before we can be certain this method has any real practical value If proven successful it could indeed overcome many of the present obstacles, including frost damage, delayed ripening because of cold weather as well as outbreaks of botrytis which can occur late in the season and with devastating results.

Many questions do arise, however; Will the method be successful with such subjects as the orientals, which bear seeds having hypogeal germination. Just how early can we remove the seed from the pods and dry them -- nine weeks, eight weeks, seven weeks from the date of pollination? Again, there are seeds of some lily species, as well as their hybrids, which are very difficult to germinate once they reach the truly dormant stage. Will the seeds of such types, if taken in the green stage, germinate any better or much quicker?

I should make one suggestion here: When green seeds are collected and are not to be sown immediately they should be slowly dried. No artificial heat need or should be used. I suspect that quick drying would cause undue shrivelling and distortion. The results would be inferior seeds.

All lily growers in Ontario, and elsewhere for that matter, know the limitations imposed upon us by the weather and environment.

We are all well aware of the fact that such lilies as the orientals and the western American species and their hybrids have great difficulty in gracing our gardens very long. The orientals do quite well when given some winter protection, while the performance of the western Americans can only be described as "spotty", for only in the occasional garden do they succeed.

It is very possible that much of the trouble, inherent in such lilies, can be overcome, although of necessity the task will be a slow and somewhat laborious one. Variation to some degree exists within each and every species. Incidentally, the wider the distribution of the species the greater will be the variation within that species. A species such as say, L. pitkinense, with its extremely limited habitat will have only minor variations. But some western American species vary so greatly that many of these forms are classified as being varieties. L. parryi, for example, has a variety found growing wild in high mountainous regions and hence is better adapted to colder areas. L. columbianum, with one foot in northern Californis, reaches north to Idaho, Oregon, Washington State and on to British Columbia. Considerable variation exists within the species; some forms grow at sea level, others at elevations of 5000 feet or more. Other forms of this species are found growing in dense shade, others demand bright sunlight. L. pardalinum is another species with wide distribution in the wild and with considerable variation between the various forms.

A similar state of affairs exists within the speciosum group. Variation consists of differences of flower type, height, vigor, number of flowers per stem, type of foliage, disease resistance, and hardiness. What a wealth of material is at hand from which to select forms which, in turn, will produce lilies that are far more amenable to our own environment.

Another fact that should be understood is that most of the above mentioned lily types, and particularly their hybrids, were raised, grown and selected in environments totally unlike our own.

I am thinking about the west coast states. If we wish to overcome this handicap and get the most out of these beautiful lilies then we will have to start all over again and allow OUR environment to do the selecting.

Any of our members who feel that they would like to make some contribution to lily improvement could well attempt this method; it is simple to understand. Suppose we use pardalinum as an example. The ideal way would be to acquire as many seeds as possible, and from as many sources as possible so as to ensure as much variation as we can expect to find within this species.

Because the enviroment will play a major role in the selection process germination will be relatively low while the mortality rate among the resulting seedlings could be high. The resulting progeny should be given good cultural treatment but without the grower actually trying to simulate west coast conditions. Once the resulting plants reach maturity the grower will have to begin thinking about producing the next generation. Only one yardstick should be used in selecting further breeding material -- just how well has each individual seedling withstood our enviroment. What we are really asking ourselves, however is .... just how well has each seedling shown its ability to adapt. Flower colour and form should be ignored. Breeding material should be selected purely on the basis of how well it has grown. Other characters can be adequately dealt with when a healthy dependable strain, growing comfortably in the garden, has been developed. With a little luck each succeeding generation should show some improvement in dependability.

Today, of course, there are a number of varieties of both orientals and west coast lilies growing in our gardens. Needless to say some have shown much more dependability than others. A start could be made with such varieties because they have already shown some measure of adaptability to our environment.

The method I have outlined is not entirely new, of course; in fact, it parallels Charles Darwin's theories of the adaptation process as related to plants, birds and animals. Hence, those wishing to take a hand in lily improvement can do so with confidence.

One lily character that has always interested me is that of leaf and stem colour. In the asiatic group, for instance, there are many examples of lilies having dark red stems and leaves. It is usual for such lilies to have dark red flowers -- the darker the flowers, the darker will be the leaf and stem colour. The red does appear to be a definite corelation between flower colour and stem and leaf colour. It does seem to me that the genes responsible for flower colour are also responsible, in whole or in part, for such colour in other parts of the plant -- leaves, stems and even the bulbs.

At this point I will digress for a moment and turn to L. candidum. About ten years ago I carried out many tests using paper chromatography to ascertain if there was any type of pigment in the glistening white flowers. I was ultimately forced to the conclusion that no colour pigment of any kind was present. I also understand that Carl Feldmaier of Germany recently carried out similar tests, and with similar results. Hence, it is well within the bounds of possibility that inhibitors are responsible for the absence of colour in L. candidum flowers. Because of this the Madonna Lily has come down through the ages quite unable to form any pigment. However, close relatives of the Madonna Lily carry the wide red colour -- L. monadelphum, for instance.

At this point, one questions arises; if the red or dark red flower colour of lilies spill over to the leaves, can this process be reversed? With this in mind I did manage to acquire a few bulbs of a dark red-stemmed L. candidum. This form has always been a rarity in gardens - and in the Wild - and is now almost impossible to get hold of. Now.. if the dark red colour is present in the stems then such plants must be carrying genes of that colour. If crossed with the normal L. candidum the colour would not be passed along to the flowers of the offspring because of the colour inhibitors present.

But crossed with June Fragrance with its yellow inheritance and creamy-yellow flowers, the dark red stem colour might, somewhere along the line, be induced to spill back to the flowers. It could also be tried in another way; The beautiful L. x testaceum is the result of crossing L. candidum with L. chalcedonicum. But no seedlings resulting from this cross, or any backcross etc., have any deeper colour than the bright, light orange red of L. chalcedonicum. However, if the cross L. candidum (dark red stemmed variety) x L. chalcedonicum was to be made it could conceivably produce seedlings having a much wider range of colour, including black red, thus bringing a new dimension to this group.

Lily flowers having papillae have always interested me; perhaps "fascinated" would be a better word to use. To acquire a fuller understanding of the change papillae bring about in a flower just take a look at any of the speciosums then try to imagine what it would look like without the papillae. These latter most certainly give considerable additional character to the bloom. I think that most people would find the flat, smooth tepals considerably less attractive.

Occasionally we find papillae on flowers of asiatic seedlings and in my view such specimens show considerable advancement over normal flowers. It should, of course, be quite possible to incorporate this character into the asiatic group. At the present time there is no literature on this subject and as far as I am aware no research has been carried out. Hence, we will have to start from scratch and learn as we go along. Some three years ago I did make a cross between two asiatic seedlings. Both were siblings of the cross 1166. One was a spotless outfacing yellow, the other a spotless up-facing apricot. Both had flowers heavy with papillae. At this stage it is much too early to make observations except to say that the character is recessive and also that there are possible other interesting genes at work.

Perhaps some of our members who are interested in breeding asiatics might also be interested in developing this character.

Another project I have been interested in is that of pollination. Usually, the procedure followed is to open the flower bud sometime before it would open naturally, remove the anthers, then place an aluminum cap over the stigma and style. Not everybody uses protectors, however, in spite of the fact that it is the only way to ensure the accurate parentage of the resulting offspring. Two or three days later the aluminum protector is removed, the pollen applied to the stigma, and the aluminum cap replaced. The removal and replacement of the cap is not always an easy one and often the reproductive organs are damaged.

Before going further I should point out that the critical time to apply pollen to lily stigmas is twenty-four to forty-eight hours after the flower actually opens. Some lily flowers will accept pollen and set seeds when pollen is applied after the tepals have faded. In the plant world the critical time for pollination varies greatly -- from two to three days before opening to some time after the flower has faded and also after petal drop.

Last year I carried out a simple test. I selected fifteen buds (estimated at two to four days before normal opening), removed the tepals from each one and also removed the anthers. The variety selected was the asiatic Orange Light. Pollen from a seedling known to have sound, fertile pollen was then applied to the stigma of the selected flowers and the styles covered with a protective aluminum cap. In due course the capsules swelled out naturally and later produced seeds. Unfortunately, I failed to make a seed count. However, if we accept this test then it would appear that the entire operation can be carried out at one time, and prior to flower opening and hence at a time when the stigma has had no chance of becoming contaminated by undesirable pollens.

The removal of the tepals was carried out because flower colour attracts both insects and hummingbirds. It is merely an extra precautionary measure.

Many similar tests with various types of lilies will have to be carried out before this method can be approved. If subsequent tests verify the results of this first one then it would seem that the best method to use when crossing lilies is to (1) select flower buds one to three or four days before opening and remove tepals and anthers. (2) Place the required pollen, and plenty of it, on the stigma, then cover with an aluminum cap. Many amateur hybridists do not bother to protect the stigma to prevent contamination, but the procedure can be carried out just the same. The pollen will remain on the stigma until such time as it becomes receptive and it can then proceed to send the pollen tube down the style.

One character which I believe we should pay more attention to than we presently do, and have certainly neglected it in the past, is the colours on the reverse side of the tepals. We have judged lily flowers merely on their "face value" for too long. But we have now reached the stage in lily development where we can no longer tolerate lilies with a beautiful face colour while having a far from desirable reverse, possibly stained with green or an unattractive dull red, or both.

To rectify this situation is a simple matter for any breeder. It merely consists of selecting better breeding material for use as parents -- plants having flowers with both sides of the tepals free from contaminating colours. The red colour usually seen on the reverse sides of the tepals is derived from the tepal ribs. Normally this colour would be confined to the ribs, but due to some small genetic malfunction it has escaped and becomes spread over much of the tepal reverse. Green colouration, however, is something quite different. Prior to opening the lily buds are quite green; the green pigment, of course, is chlorophyll, a very complex chemical substance. As the flower approaches the opening date the green chlorophyll, in a typical impulse-response action, begins to disappear; in fact, the disappearance is quite rapid.

However, in some cases the green pigment does not wholly disappear; some remains to contaminate. I am not sure what really happens to the chlorophyll - whether there is a complete breakdown of the chlorophyll molecule or whether it undergoes a chemical change and is used in the synthesis of the flower pigments.

# PART III

# CONSIDER THE LILY

This article is an attempt to give readers an insight into the structure and function of the subject we are all so keenly interested in, the lily. A full understanding of the subject should enable us to achieve much better results in the garden and the flower show. For the sake of convenience the article is divided into four sections - roots, bulb, stem and leaves, and flowerhead. We will begin with the roots.

## THE ROOTS

Contractile Roots: The roots of lilies form an unusually complex system composed of contractile, basal and stem roots. The contractile roots have two main functions - (1) to anchor the bulb and prevent it moving in the soil during periods of high winds or when top growth is unusually heavy; it thereby prevents damage to the slender and easily broken feeder roots. (2) to pull the bulb deeper into the soil and to a depth most suitable for its natural requirements. This 'pulling down' is accomplished by a peculiar shortening of the roots. Depth requirements may vary considerably. Most lily types, depending on the natural conditions in which they were evolved, demand a particular depth of soil: Most asiatics require approximately four inches of soil above the bulb although L. wardii and L. polyphyllum require six inches to a foot or more above the bulb. In its natural habitat, the Himalayas, bulbs of the latter species are often found at depths of almost two feet. The contractile root plays a very important part in the development of the seedling which begins life at or very near the soil surface. As the tiny bulb develops it is drawn downward to a suitable depth. This depth is determined by the size of the young bulb as well as soil conditions; such conditions are governed mainly by aeration and the size of the soil particles Thus, soils having microscopic-sized particles, such as clays, offer much more resistance to the downward pull than soils having a higher humus level and hence have larger soil particles and better aeration.

Contractile roots are larger and thicker than the feeder roots and normally show wrinkling of the surface. Like the basal feeder roots they are formed at the edge of the basal plate of the bulb. Ultimately they may branch out and also act as feeder roots.

<u>Basal Feeder Roots:</u> These are also formed on the bottom of the basal plate, usually around the edges. Like the stem roots they function primarily in the absorption of soil water and nutrients, passing them into what is known as the xylem which, in turn, transports them upward to the leaves where they are used to produce plant foods. Basal feeders are much more important to the lily plant than are the stem roots; although both perform the same function the fact is that the basal roots supply both water and nutrients to the plant long before the stem roots are formed in the spring, and are still functioning in the fall after the stem has died. Unlike the stem roots, which are annual, the basal roots usually persist for more than a year although their maximum life is under two years and thus are constantly being replaced. This replacement takes place mainly in the spring and early summer.

<u>Stem Roots:</u> These arise at the base of the stem between the soil surface and the bulb. An examination shows their origin to be at random on the stem or issuing from each node in a somewhat spiral order. These roots are much smaller and finer than the basal feeder roots and are much smaller and finer than the basal feeder roots and are much branched.

Although short lived, the stem roots are nevertheless extremely important to growth and development. Where damage has been done to the bulb or basal roots - from nematodes or other insects, rodents or diseases - the stem roots are quite capable of carrying the aerial part of the plant to a successful completion of growth, flowering, and even seed production.

However, as the aerian parts as well as the stem roots die in the fall, the damage to the bulb and basal roots may not be apparent until the following spring. Not all lilies have stem roots; species such as L. candidum and several of the European natives have few or no stem roots.

Few lily growers, particularly those who exhibit, take full advantage of the possibilities the stem roots offer. Because they are young and vigorous in the spring when they reach out for nutrients the lily grower can see to it that they have an excellent, well-balanced soil medium so necessary for the production of quality blooms. This can be achieved by removing the soil surrounding the stems to the depth of the bulb and replacing it with new soil having the necessary texture and nutrients. This operation, of course, must be carried out in the fall and not when growth has started in the spring.

Having given an account of the lily's root system, a short description of a root and how it functions is necessary. If we examine a young root through a microscope we will find four fairly distinct cell regions, one above the other. At the very tip of the root is region A, the root cap, a thimble-shaped mass of moderately-sized cells which have two basic functions; (1) to protect the dividing meristematic cells immediately above this cap; (2) this root cap is constantly being pushed downward or outward through the soil and thus the cells which form this root cap are being subjected to the abrasive action of soil particles and are broken off or damaged. As this happens new cells are formed to replace them. Immediately behind the root cap is (B), the meristematic region. This is the area where growth of the root is taking place by cell division. This meristematic region consists of a mass of almost cubical, thin-walled cells containing dense protoplasm in which are embedded the nucleus and the chromosomes. The elongation region (C) is situated behind the dividing meristematic area and consists of cells undergoing enlargement, particularly in length.

It is perhaps a matter of interest that these two regions - meristematic and elongation -- do not exceed one or two millimeters in length, but are extremely important relative to their size. The region immediately above this elongation, region (D), is known as the maturation or differentiation region. At this stage the enlarged cells become the mature tissues of the root. Embedded in these root tissues are two important organs, the xylem and the phloem; the xylem conducts water and minerals in solution upward to the leaves, while the phloem functions chiefly for the downward conduction of the synthesized foods to the storage areas, mainly the bulb.

The four regions of the root have been described to show how the root grows and matures. However, this process is also carried out in other parts of the lily plant, particularly at the growing tip of the stem. But we have not as yet discussed the root's most important function which is the absorption or intake of water and mineral nutrients by the living root cells. The absorption of water and dissolved minerals in the form of nitrates, sulphates, phosphates, etc., by the cells is a rather complex phenomenon which is not fully understood. One of the important factors in this process is diffusion. Thus the solutes - water with minerals in solution - move from regions where they are more abundant. (e.g. the soil, to regions where they are less abundant, e.g. root cells). Cells are selective in their nature and are capable of controlling the kind and precise amount of mineral substances entering the cells. Thus these mineral substances enter the roots, pass into the xylem and make their way to the leaves.

One fact we should all bear in mind is that the lily plant is only as good as its root system. The better the root system, the better the plant. So the question is ... how do we develop an excellent root system? First, plant only healthy, plump bulbs which have clean, strong roots, perfectly free from disease or even suspected disease.

Second, provide a soil medium which has a good base and is well-drained. Roots also breathe and hence require air. A well-drained soil provides air and never becomes water-logged; hence it can be said to be always sweet. Water-logged soil is very destructive of the soil organisms by virtue of the fact that oxygen, so necessary to life even in the soil, is driven out by the excess water, causing the organisms to die. When this environment is destroyed a considerable period of time must elapse before the organisms can again invade the soil and restore its health as well as the health of the plants growing in it. Where necessary, provide adequate humus to ensure ample water and good texture for easy penetration and growth by the roots. Third, make certain there is ample plant nutrients at all times during the growing season.

The soil requirements of liles vary greatly, as does the pH level. Generally speaking, the requirements of the asiatic group and most members of the candidum group demand a higher pH than do the orientals. These latter lilies demand a more acid soil, a higher humus content, and more moisture. The pH value of soils is an expression of the acidity or alkalinity as measure on what we call the pH scale, which runs from 0 to 14; pH7 (that of distilled water) being neutral. Values above this indicate alkalinity, below it acidity. Soils below pH5 are strongly acid, above pH8 strongly alkaline. The organic content of lily soils is extremely important. Humus assists greatly in the retention of water, prevents soil caking, and increases porosity and aeration. Furthermore, organic matter promotes the growth of soil organisms of many kinds such as bacteria, molds, algae, microscopic and larger insects, worms, and a veritable host of living things which inhabit the soil. These should be considered to be an integral part of any fertile soil. The waste products and dead materials of such organisms enrich the soils organic matter. In a soil that was basically good and has been given proper treatment by an understanding cultivator are millions of organisms in every cupful of good soil, each contributing in some way to the development of the soil.

I have emphasized the importance of soils in their association with lily roots. However, there is one exception -- the species L. arboricola, first discovered by Kingdon Ward in 1953, which grows in the crotches and crevices of trees in the humid woods of northern Burma. It anchors its roots in decayed organic matter which has become lodged in the trees. It is a most unusual lily and one which I believe has only been introduced to cultivation on one occasion; unfortunately, it lasted but a few short months and departed. We can hardly expect this species to become a power in the lily world and hence can well ignore the fact that it does not anchor its roots in soil, as do other lilies.

## STEM & LEAVES

The chief function of the stems are (1) the transportation of water, mineral substances, and synthesized food materials; (2) food storage; (3) they also have the function of producing and supporting the leaves and flowerhead. The stems of some lilies, particularly the upper half, produce bulbils in the axils of the leaves. Bulbets are also formed on the stem in the region of the stem roots. Hence the stem is also a means of propagation. Bulbils can often be encouraged to form on lilies if the stem is severed with a knife just above the mother bulb. To do this a hole should be made some four or five inches from the stem, so as not to disturb the stem roots. The knife blade can then be pushed through the soil and the stem severed. The hole should be filled and the stem left in place. I believe this method is much better than the one generally advocated -- that of jerking the stem free of the mother bulb and transplanting it elsewhere. Bulbils can also be encouraged to form on some lilies if the flowerhead is removed when in the tight bud stage.

The stem has its origin in the growing bud formed on the basal plate during the previous growing season. Lily stems, like those of most herbaceous plants, make very little growth in diameter after they emerge from the soil.

They vary considerably in height from the slender 6 inch stems of L. amoenum, a rare native of the Yunnan province of China to the towering 10 feet high L. leucanthum var. centifolium, also a China native. Although stems are commonly cylindrical and smooth, some species such as L. cernuum, L. dauricum, L. duchartrei, L. taliense and others possess ribbed stems. Some species have stems which are hairy, particularly the upper parts as well as the buds. Sometimes these hairs are so numerous that they give the parts a woolly appearance. Species such as L. bulbiferum var. croceum, L. davidii, L. papilliferum and L. tigrinum possess these hairs which are in reality outgrowths of the epidermal cells. Many asiatic cultivars possess this characteristic.

At the very tip of the growing stem is the meristematic region where there is a mass of rapidly dividing and growing cells. Seen through a microscope at a low power the shoot tip is a pale, waxy cone composed of minute interfolded leaves so tightly growing together that they appear almost as a solid mass. However, when these microscopic leaves are "teased" out and removed, the primordial stem tip is exposed. This tip is virus free by virtue of the fact that the virus organisms within the mother plant have not had sufficient time to invade the newly formed tissues. If this primordial tip is removed and cultured on a nutrient medium under completely sterile conditions, a new virus-free stock of young plans can be acquired. Several large commercial lily growers are now using this method of propagation. It must be remembered that meristematic culture is only used for the propagation of asexually produced hybrids; it is not necessary when seeds are used for propagation because lily seeds do not transmit virus to the progeny. The tip of the stem is somewhat similar to the young root in its structure, having meristematic, elongation and maturation regions.

The stems of lilies, as with most monacatyledons, have no cambium layer.

Hence, there is no secondary growth or branches except on fasciated plants. But as fasciation is abnormal, this type of branching should be ignored. The principal function of stems is the upward conduction of synthesized foods through the phloem. What causes this movement of solutes through the lily plant? transpiration (evaporation) of water from the leaves causes a water deficit in the leaf cells. As a result, water is drawn osmotically from the xylem cells in the leaf veins. Thus a pull is exerted in the sylem cells and the pull thus exerted is transmitted through the water columns in the xylem right down to the roots where it is replenished from the moisture in the soil. Put simply, water with minerals in solution is pulled up through the stems by the evaporation pull from the leaf surface -- through the stomats. The above description is, of necessity, a simplification of the actual process; cell action, root pressure, capillary action, atmospheric pressure and imbibition appear to assist in the process, but in a very minor way.

The downward conduction of foods manufactured by photosynthesis in the leaves is through the phloem. The forces responsible are not well understood. The rate of such conduction is much too rapid to be explained by simple diffusion.

## LILY LEAVES

A lily leaf is a laterial outgrowth of the stem and some of the functions of the leaf are also carried out by the stem. Thus, photosynthesis which is mainly carried out in the leaves can also be accomplished in the green parts of the stem. Lily leaves vary considerably in size and shape as well as in the arrangement on the stem. They may be in tiered whorls with several inches of stem between each tier, as illustrated by <u>L. martagon</u>, or the leaves may be arranged spirally up the stem as in <u>L. regale.</u>

Some of the western American species are intermediate in this leaf arrangement having both whorles and scattered leaves on the stem, as is occasionally exhibited by L. parryi. Another good example of intermediate leaf arrangement is L. hansonii from Korea and the nearby Dagelet Islands. In true lilies the leaves rarely exceed two inches across. Some species such as L. cernuum, L. pumilum, and L. callosum have narrow grass-like foliage, a characteristic which usually denotes their having been evolved in a dry, arid region. The colour of leaves can also vary through all shades of green to a deep blackish red.

The leaf blade is flat and thin, and at all times exposed to the maximum amount of sunlight from which the plant derives its energy. Furthermore, carbon dioxide can readily penetrate all parts of the leaf. This carbon dioxide, water and oxygen, with the assistance of chlorophyll and the energy from the sun, will form the carbohydrates so necessary for plant nutrition. The minerals derived from the soil combine with the carbohydrates to form proteins, the most important substance of which living protoplasm is made. Proteins are also responsible for the production of oils and fats which are found in the seed endosperm. But one of the most important features of the leaf are the stomata which can best be described as avenues of exchange of carbon dioxide, oxygen and water vapor between the interior of the leaf and the outside atmosphere. Naturally, the function of the stomata can be hindered by dust and grime covering the leaf surface. Under normal circumstances summer and spring rains will cleanse the leaf surface; however, in some locations which are adjacent to a dusty highway the grower should take some action to clean the lily plants. An occasional spray with the hose will do the job but be sure to select a warm, dry day -- a day that will minimize the risk of attacks from botrytis.

The veins of the lily leaf are parallel and unbranched and are actually continuations of the vascular bundles - xylem and phloem - of the stem and leaf petioles.

The larger veins are surrounded with thick-walled cells which strengthen and then help support the leaf. Lily leaves arise from the meristemic or growth tissues at the very tip of the stem, and which has already been described. They arise as lateral protuberances or nubs of the bud tip; as the protuberances grow they become differentiated into leaves. Lily leaves, like the stems, are very sensitive to light, and light is essential to photosynthesis. Light also exercises considerable influence on the rate of growth, formation and effectiveness of hormones, formation of chlorophyll, leaf size and digestion. Because light is so important, lilies should be planted in situations where they receive a minimum of four hours of sunshine each day. Many authorities are prone to say that lilies do best when they have the base of the stems and the surrounding soil in the shade of nearby shrubs, but with their heads in the sun. This is probably true, but such conditions are not normally available in the average garden and lily growers have to use whatever space is available to them. Where the soil has a good moisture retaining capacity it will be found that the more popular garden lilies such as the asiatics, trumpets and aurelians are capable of doing quite well in full sun. However, we must realize that lilies vary in their light requirements and that a few require a little more shade. Thus growers should study the requirements of the particular lilies they are interested in and treat them accordingly. The margins of lily leaves can vary greatly. For instance, they can be ciliate (fringed with fine hairs), undulate or wavy as with L. candidum, or they can be silver-margined as with L. pomponium, and so on.

## THE FLOWERHEAD

The flowerhead develops from the previously discussed meristematic tissues located at the tip of the growing stem. The main axis, which is merely a continuation of the stem, is called a peduncle while the shorter stems which bear the flowers are called pedicels.

Both the peduncle and pedicels are merely extensions of the stem and encompass the vascular bundles responsible for the up and down flow of nutrients. In a few species the flowers are borne singly, as with L. catesbaei and and L. neilgherrense, while at the other extreme is L. davidii var. willmottaie which has been known to bear almost eighty flowers on a good specimen. It is usual for a pedicel to bear a single flower although it is not uncommon for some kinds to bear two flowers, or even three - as is usual with a well-grown 'Nutmegger'.

The flower arrangement of most lilies is racemose, that is, the flowers are carried on pedicels around an elongated peduncle. In some lilies, however, the stem from which the pedicels arise is so short that they appear to have arisen from a common axis -- like the ribs of an umbrella.

Monocotyledons have their flower parts in threes or multiples of three, and as with many liliaceous plants the flower parts of lilies can be said to be in the order of three or six. Thus, we normally find six tepals, six filaments, six anthers, and six rows of seeds within a three compartmented (locules) capsule. The stigma is three-lobed. The type of flower can vary widely and this characteristic is used, of course, in lily classification. Just how much the tepals recurve and how the flowers are held, whether upfacing, outfacing, or pendulous helps to determine the status of a lily. The six slender filaments carry delicately poised anthers in which the pollen is located. The colours of the filaments, anthers, and pollen are also used to classify lilies. Near the base of each tepal is the nectary furrow which secretes the concentrated sugar solution so beloved by hummingbirds and which is known as nectar. The colour of the tepals, the nectar, as well as the fragrance of some species serve to attract the insects so necessary for natural cross-pollination. The tepals also secrete minute droplets of the aromatic oils responsible for the fragrance of so many species and cultivars.

A few of the fragrant species are: L. candidum, L.pumilum, L. auratum, L. henryi, L. monadelphum, L. wardii as well as the hybrids L. x testceum and L. x June Fragrance, among many others. Some specimens such a L. amabile and some of the European species such as L. pomponium and L. pyrenaicum possess flowers which have unpleasant odors. Some tepals are clawed while others have minute projections known as papillae. L. speciosum and its varieties are good examples. Some asiatics also bear flowers having papillae; in fact I have on occasion seen plants with papillae appear among seedlings whose parents bore no papillae. Although the lily flower normally has six tepals there is a variety of L. tigrinum which has fully double flowers. L. martagon is another species which has a double-flowered form. This latter, I believe, is still grown in a few Swedish gardens.

The filaments arise near the base of the tepals and are occasionally attached to them. The species L. monadelphum has the filaments bonded together at the base, containing two nuclei, a tube nucleus and a generative nucleus. Pollen is formed from the pollen mother cells located in the anther sacs. Each mother cell forms four pollen grains; each pollen grain carries twelve thread-like chromosomes which is the half or haploid number carried by the parent plant. The largest of these chromosomes is about 1/1000 part of an inch long. These are the male's contribution to the next generation. The ovules also carry a similar number and these, of course, are the female's contribution to its progeny. The normal chromosome complement of the lily is twenty-four. However, several varieties of L. tigrinum possess thirty-six and are therefore triploids. They are quite sterile.

The pistil is the female reproductive organ consisting of an ovary or potential seed capsule, above which is the style with its three-lobed stigma. Lily styles vary in length from about one-inch in the species L. pumilum to four or more inches in the orientals.

The stigma, as it becomes mature enough for pollination, issues a muscillaginous fluid to which pollen adheres. This fluid contains a hormone which assists the pollen to germinate. The pollen also contains a hormone as does the style, the ovules and the ovary. Each must make its contribution before viable seed can be formed. It is possible for two or even more kinds of pollen to germinate on a stigma at the same time, penetrate the stylar tissue and fertilize the ovules within the ovary. In this case a mixed bag of seedlings is inevitable. Lily species and their hybrids will not normally set seeds if pollinated with their own pollen. This is said to be self-incompatibility. I believe this to be due to a chemical inhibitor or hormone located in the stigma and style, if such pollen is similar, genetically or physiologically, to the tissues of the style. As far as I am aware the inhibitors either prevent germination or slow down the growth of the tubes to such an extent that they fail to reach the ovules before degeneration sets in. Some research has also shown that in certain cases the pollen tubes can burst as they make their way down the style. There are probably other contributing factors. This incompatibility is a problem lily breeders often encounter when attempting to cross siblings - closely related plants, such as two plants having the same parentage.

A look at the pods of several lily species or varieties illustrates very clearly the considerable variation in size and form of the seed capsules. Whether the capsule contains a full complement of large plump seeds or whether only partial fertilization has taken place also plays a part in determining the size and shape of such capsules. Where only partial fertilization has taken place the capsules can be quite irregular in size and shape.

Lily seeds are extremly light and thin. In their natural habitat they are wind distributed. A papery, membranaceous border surrounds the endosperm which is the food reserve for the embryo.

The embryo of a lily seed begins to digest and utilize this food reserve, in which it is embedded, as soon as the seed is planted and there is sufficient moisture and warmth for it to abandon its dormant state and grow. To germinate successfully, lily seeds need warmth ($50^{o}$ F to $70^{o}$ F.), air and moisture. A soil medium which is well-drained and yet has a good moisture retaining capacity because of its humus content can be regarded as a good medium -- providing it has adequate fertility. At all times the soil which is in contact with the seeds should be moist to ensure adequate water intake by the seeds at this most critical stage. At no time should the seeds be allowed to dry out.

By the way seeds germinate they can be divided into four distinct groups: (1) epigeal, immediate germination: (2) epigeal, delayed germination; (3) hypogeal, immediate germination and (4) hypogeal, delayed germination. Those seeds with epigeal immediate germination produce, after about four weeks of incubation, a down-growing root followed later by a loop-shaped cotyledon which pushes through the soil with the seed coat still attached. The first true leaf appears two to four weeks later. Those seeds having hypogeal immediate germination (group 3) can be treated in much the same way as the epigeals; the epigeal, delayed germination kinds are also treated much the same way although they take much longer to form both root and cotyledon. An important group to many lily growers is the hypogeal, delayed germination, which acts quite differently to the other groups and requires different treatment. They need a three-month period at a temperature of $70^{o}$ F., which stimulates bulb growth. This must be followed by a cold period of no less than six weeks at temperatures ranging from $35^{o}$ to $45^{o}$ F. which encourages leaf growth. These rules are not hard and fast, in fact, even researchers are still in the learning process. It is more usual for amateurs to keep these delayed hypogeals at room temperatures for the first three months, then remove them to either a refrigerator or cold room. The seeds of the American species should be kept some $10^{o}$ F. below that for the orientals.

The raising of seeds having delayed hypogeal germination is much more difficult than those with epigeal germination and this is further complicated by the fact that certain growth inhibitors, notably ferulic acid, is a toxic substance which attacks and destroys the embryos of many oriental hybrids. However, it has been shown that washing the seeds in running water prior to sowing has proved advantageous as it removes the ferulic acid by leaching. Both Showalter and Emsweller have demonstrated that at germination it is the cotyledon which emerges first from the seed and not the radical (root), as in the case of the epigeals. A tiny bulb is formed at the end of the cotyledon and the root later emerges from the base of the small bulb.

Under normal circumstances, and where effective fertilization has taken place, the seeds will contain both endosperm and embryo. Sometimes, however, particularly where a wide cross has been made, some seeds may contain embryo but no endosperm, others endosperm by no embryo. Where the former has occurred -- embryo but no endosperm -- the culture of the embryo is the only method open to the hybridizer if seedlings from the cross are to be obtained. This is carried out by dissecting the seeds while in the green stage of development, carefully removing the embryo and culturing it in a nutrient medium under absolutely sterile conditions. This procedure is only carried out as a last resort and when there is no other avenue of approach. It can be very rewarding; it can also be very disappointing.

## FLOWER COLOURS

In recent years geneticists and biochemists have collaborated in studies of flower colours and have given us much useful information concerning the chemical nature of such flower colours as well as the role played by the genes in determining a particular colour or pattern.

For the purpose of convenience, flower colours are grouped into three classes: (1) the anthocyanins which give us the red and blue colours of flowers -- lilies do not possess any genes for the production of blue; (2) the anthoxanthins which contribute colours from pale ivory to deep yellow and (3) plastid pigments which provide us with orange and yellow. Variations within these classes is brought about by genes whose actions modify colours. Thus, colours can be intensified, diluted, or an increase or decrease in the amount of available colour can be brought about.

The anthocyanins: The anthocyanines are extremely important as they are mainly responsible for the dark reds, reds, scarlets, orange-red, fuchsia and pink colours found in lilies. Although lilies do not possess blue colour some growers insist that they can detect a slight haze of blue in some white or pale lilac lilies. On occasion I have noticed this "cold" white or lilac haze but believe this is due to the fact that the cell sap is unduly alkaline -- the action is similar to that of an alkaline solution which turns red litmus blue. The anthocyanins occur in the cells of the flowers as sap-soluble glycosides and are not particles of colouring matter with one or more molecules of a sugar. There are many types of these anthocyanins, bearing such names as pelargonidin, malvadin, delphinidin, etc., which gives us some idea of the particular colour they represent. However, they differ only slightly in their chemical formulas.

The anthoxanthins: These are closely related, chemically to the anthocyanins although they do differ in the colour they produce, which ranges from a pale ivory to a rich, deep yellow. The anthoxanthins, too, are sap-soluable and like the anthocyanins are mainly glycosides. They fall mainly into two classes, the flavones and the flavonols, although these too can be broken down into several subclasses.

There are four ways in which this group is involved in flower colour: (1) Where there is no anthocyanin present they may be responsible for all the flower's colour; (2) if an anthocyanin is present the resulting colour will be a combination of both although this is only true where both are present in the same cell. If they are in different cell layers the visual result is not a blending but rather a background effect; (3) the paler coloured anthoxanthins such as ivory have a co-pigmenting action; (4) the presence of a considerable amount of anthoxanthin may lead to the almost complete suppression of red anthocyanins, giving rise to apricot tints.

Plastid Pigments: The flower colouring substance known as plastid pigments comprise several yellow and orange substances. Unlike the anthocyanins and anthoxanthin group. Where anthocyanins are present the plastids merely act as a background but by so doing an orange colour is produced. For example, one could be looking at a yellow plastid but throught a red-pigmented sap, which would give the impression of an orange colour. The pigments xanthophyll and caretene are plastids; they are also substances which have a marked effect on lily colours, particularly the orange and deep yellows.

To summarize, the flower colours of the lily and the variations thereof are brought about by the three main colour groups, each group being made up of several basic pigments which, in turn, are chemically modified to give still more pigments. Furthermore, any one type can be present in a flower or there can be two or more types interacting to give additional colours. Lastly, these pigments are controlled by the genes whose actions are highly specific. When we take into consideration the additional effect of intensification, dilution, and pattern genes, it can readily be understood why we have such a remarkable array of colours and also what the future holds for all progressive lily breeders.

Pattern genes, of course, are responsible for laying down the colours in distinct patterns, as can clearly be seen on the flowers of red-banded and gold-banded auratums the speciosums, and many asiatics, particularly the L. cernuum hybrids.

It should be understood that some of these pigments are also to be seen in the stems and leaves of some lilies. Dark stems and leaves are often associated with dark coloured flowers. However, this is not always the case since dark stems are associated with the glistening pure white flowers of some L. candidum varieties, notable var. cernuum, which has an almost black stem colour. A point of interest is that bulbs are often strongly pigmented although such pigments are not always associated with flower colour. L. henryi is a good example - very dark bulb colour but light coloured flowers. We still have much to learn about colours. Chlorophyll, too, is a pigment; it is responsible for the green colouration of stems leaves and other parts. However, it has a dual role because it also plays a vital part in photosynthesis.

## THE LILY BULB

A Lily bulb can best be described as a large, somewhat globose perennial bud having a small basal stem at its lower end from which grow fleshy, scale-like overlapping leaves. It consists of a solid basal mass (basal plate) which is actually an extremely short stem on which the scales or modified leaves are mounted. This basal plate is undoubtedly the most important part of the bulb, and indeed the entire plant, since the basal feeder roots, contractile roots, scales, as well as the buds for all future growth have their origin here. As stated, the scales are actually leaves which have been modified for the purpose of food storage. Initially bulbs are derived directly from young developing seedlings, from bulbils formed in the axils of the upper leaves in certain species (l. sargentiae, L. tigrinum, and forms of L. henryi and L. bulbiferum etc., as well as some hybrids derived from thes species and as bublets formed at the base of the stem.

As well as those formed on scales which have been detached and used for propagation purposes. Young bulbs have the first green leaves attached directly to the scales, while L. candidum has the leaves which make up the winter rosette attached directly to the scales of the mature lily bulb. These leaves, therefore, are merely above-ground extensions of the scales.

The scales of the lily are fleshy and succulent and have a more open arrangement than those of its closest allies, the onion and the tulip. Consequently, excessive soil moisture -- such as occurs in poorly drained soils, invite attach from noxious organisms which find their way between the scales and destroy the heart of the bulb. In some cases the scales are formed from the swollen bases of leaves: L. catesbaei is a good example of this and once the green upper part has been cast off, a terminal scar results which give the leaves a ragged appearance, as though they have been chewed off by mice.

The scales are imbricated, meaning they overlap. They vary considerably in size, form and colour. They can be toothed, as with L. wallachianum, long and narrow as with L. humboldtii and L. polyphyllum, which gives the bulb a slender appearance. They can be short, broad and thick. With certain species such as L. philadelphicum, L. parryi, L. pardalinum and L. medoloides the scales are constricted or jointed although in actual fact they appear to have a waistline. This type is usually more fragile than non-constricted scales and in my experience do not propagate as readily. The number of scales varies from species to species, in some cases quite considerably. Thus, species like, L. callosum, L. pumulum and L. leichtlini have few scales; L. henryi and L. regale have more numerous scales and much larger.

A bulb in the soil does not remain unchanged; as a matter of fact it is replaced annually by producing a growing bud on the basal plate and surrounding it with newly formed scales which grow rapidly as they fill up with food materials from the leaves and which has been transported downward through the phloem.

We must recognize the fact that bulb replacement depends largely upon a strong, healthy root system and equally healthy top growth. If these two factors are not present then the lily plant may be quite incapable of growing a new bulb, in which case it dies. In one growing season the newly formed bulb should grow to approximately the same size as the mother bulb it replaces or even larger. Some American lilies, however, have a different method of bulb replacement; the new bulb is produced outside of the old bulb and hence moves into new soil. Some of these species push out a scaly, finger-like outgrowth at the end of which the second bulb forms. This new bulb will flower the following year and then increases in a similar manner. The old bulb will die after first having passed its remaining food reserves to the new bulb. The outgrowth is known as a stolon; it continues to, and through, the new bulb and into the flowering stem. Each season a new stolon is formed. Such bulb types which are confined to the American species (examples L. michiganense L. canadense, L. superbum) are said to be stoloniferous. A few asiatic species, notably L. wardii, are described as being stoloniform -- not to be confused with stononiferous. In such cases the stem, as it arises from the bulb, runs horizontally underground for some distance before emerging from the soil. The difference is that in the latter case, stoloniform, it is the stem that is referred to whereas stononiferous refers to the appendage of the bulb.

There is still another type, termed rhizomatous, in which the scales are formed in clusters along a thick, perennial branching rootstock or rhizome. L. pardalinum and its many forms are of this type. Although it may make matters a little more confusing it must be pointed out that there are bulb types intermediate between the types above described. Thus, L. washingtonianum and L. humboldtii are examples of intermediate forms between L. pardalinum and L. michiganense. Such bulbs are said to be subrhizomatous - something less than a true rhizome.

The natural increase of bulbs also occurs by the splitting of the mother bulb into two or more bulbs, each of which can be almost as large as the parent bulb. These are formed from strong healthy bulbs which because of their vigor have formed more than a single bud on the basal plate. They have also been able to draw from the parent bulb all the nutrients necessary to form more than a single bulb.

After planting, which is usually carried out in the fall, bulbs normally begin growth early the following spring. There are exceptions to this however; the species L. monadelphum and L. szovitsianum and several others of the caucasion group lie dormant for approximately eighteen months before emerging from the soil.

Scales can be used as a quick and very practical means of propagation if they are removed and placed in a suitable medium. Furthermore, it has now been established that if they are sterilized on removal from the bulb and grown in sterile nutrient medium, and if the newly formed bulblets are removed when very small, a goodly percentage should be quite free of virus. Which are free and which are carriers can only be determined by testing. Scales also form callus tissue which can be removed and cultured to form bulblets, and these too, may be free of virus infection. Callus is an undifferentiated, tangled mass of cells through which virus travels but slowly because there is no vascular tissue to serve as pathways for these organisms. This method of propagation is proving to be an excellent way of raising clean, virus-free stocks.

# PART IV

# LILY SOILS AND ENVIRONMENTS

The subject of soils is never an easy one for discussion, for many reasons, the main one being that we all reside in different localities and have different soil types. Such soil types vary from area to area, often changing from one type to another within a particular garden. Hence, no rules can be laid down which will benefit all lily growers and to attempt to do so would only result in confusion.

There are, however, certain aspects of soils and their relations to lilies that can help growers to achieve good or even excellent results when such knowledge is properly applied. This is particularly true of lily species which are found growing in their native haunts under widely different conditions. It is also true of their hybrids, and a knowledge of the many soil types in which lilies grow in the wild, and the way in which such soils are formed, should assist in a better understanding of soils in the garden. Climate has a profound effect on the nature of our soils - different climates, different soils. Consider then the intensely hot summers yet icily cold winters of Siberia, the hot and humid climate of Burma, the relatively cool and damp climate of the North American Pacific coastal region, the short winters and long summer of the temperate Mediterranean area, the relatively short summers and long winters of those regions inhabited by the species canadense, superbum, michiganense, grayi, philadelphicum, etc. Thus we have different climates, each forming its own soil type. We cannot modify our climate, of course, but we can do something about our soils in an effort to make them as congenial and fertile as we possibly can for our lilies. In other words, we modify our soils in such a way that it greatly assists many of the world's lilies to adapt to our environment.

Another aspect which cannot be overlooked is that of soil fertility. Some lilies demand relatively fertile soils while others such as L. philadelphicum prefer dry and often very barren soils in which to exist.

A similar situations exists in the soil moisture requirements of the various lilies. The asiatic, trumpet and aurelian hybrids require soils having only a very modest moisture content whereas the orientals and western America species and hybrids usually demand soils having a much greater water-holding capacity. Thus it will be seen that the successful growing of lilies can be a challenge; it can also be very rewarding. Fortunately the task is not as awesome as some believe, and the reason is not far to seek. Many lilies, especially those commonly seen growing in gardens, are quite tolerant of soil conditions, particularly in relation to soil pH values. Thus most asiatics grown in gardens do well in soils up to pH 6.5. Thus they are far from being "very selective" in their requirements. Lilium martagon, found wild throughout Europe in many varieties and geographical forms, grows in soils varying from alkaline to sub-acid (about 7.5 to 6.0). Just as lilies mutate to form varieties having different flower colours, leaf types, heights, etc. it appears these mutants also vary in their soil requirements.

Because of the considerable variation in soil demands by lilies an attempt should be made here to bring some semblance of order to the subject by outlinining five of the factors which constitute the basic features of lily soils. They are:

(1) Soil pH value
(2) Moisture holding capacity
(3) Organic matter and humus content
(4) Mineral content
(5) Fertility level

There are other factors, of course, such as light intensity, depth of water table, exposure, winter cold, etc. These will not be dealt with individually because for the most part there is little or nothing we can do about them. However, we will touch on them very briefly where necessary.

NOTE: It will be seen that organic matter and humus are dealt with as two subjects, as they should be, because they have quite different qualities. Actually they are different as coal and coke. Humus is the end product resulting from the decay (or burning up) of the organic matter. Unfortunately most gardeners tend to confuse the two, referring to both as either humus or organic matter.

Soil pH: We will first deal with pH values, i.e. the acidity or alkalinity of soils. Because the pH value of the soil is so very important to lily growers - much more important than is generally believed - it will be dealt with at length. Just what is meant by soil pH? pH is a value taken to represent the acidity or alkalinity of a liquid or mixture of liquids. Technically (for anyone who is interested) it is defined as the logarithm (base 10) of the reciprocal of the hydrogen ion concentration per litre. Thus we do not measure the pH value of soil solids, such information would have little value because solids cannot be absorbed by the plant through its root system. Only liquids and the nutrients which are in complete solution can be absorbed by the root hairs. The nature of the solids which make up the soil do, however, determine the pH value of the soil water which upon passing into the root system determines the plant's growth. The nutrients in solution are chiefly nitrates, phosphates and sulphates. The pH scale is not like a foot rule where the difference of one inch means the same thing all along its length. It is a logarithmic scale and the differences become greater as they move further from the neutral point of 7.0.

The relationship between soil moisture and the nutrients it contains can be used to advantage by lily growers. Mineral fertilizers should only be applied to soils having a good moisture content. The nutrients contained in the fertilizer can then become dissolved in the soil water and thus be absorbed by the lily roots. It can be said that the amount of nutrients available to the plant is in direct proportion to the soil moisture content.

Thus fertilizers should only be applied when the soil moisture content is high or where irrigation is carried out. Applied when the soil is dry, the fertilizer can only remain in a solid state until the next rainfall.

The following is a list of the major soil types in which lilies are found growing in their native haunts. It has already been pointed out that lilies differ greatly in their tolerance of acidity or alkalinity. Hence, there are instances of lilies being found growing in more than one pH group. There is another and very important factor to be taken into consideration; it is that A GIVEN DEGREE OF ACIDITY IS LESS HARMFUL IN MOIST THAN IN DRY SOILS, AND CONSIDERABLY LESS HARMFUL IN THE PRESENCE OF ORGANIC MATTER.

TYPES OF LILY SOILS:

| | |
|---|---|
| Above pH 8.0 | Soils which are definitely alkaline and are of limestone origin. Many types of clay, loam and sandy soils are prevalent; even peat beds and soils of peaty origin are occasionally found. Chalky soils dry out quickly, becoming very hard The vegetation natural to such chalky soils are coarse grasses and scrub. It is unusual to find lilies thriving in such soils, and none on the more chalky type, although a few from the next lower group, such as L. candidum, hansonii, etc. may tolerate some of the soils just slightly above the pH 8.0 level. |
| pH 8.0 to pH 7.0 | The top half (pH 7.5 to 8.0) is mildly alkaline while the lower half should be regarded as neutral. The basic rock is limestone, occasionally at a considerable depth. These soils are often considerably modified. Many lilies are native of these soils, such as candidum, monadelphum, chalcedonicum, etc. |

pH 7.0 to pH 6.0 — Soils with pH levels between 6.5 and 7.0 must be considered as neutral, the lower half (6.5 to 6.0) as midly acid. These are often humus-rich soils of woodland origin, swamplands and gritty, humus rich meadowland soils. All are in calcareous regions. Much of our farm and garden land is of this type while many of our finest garden perennials, shrubs and trees had their origins in soils of this group. Such lilies as cernuum, dauricum, davidii, nepalense, sargentiae reside here.

pH 6.0 to pH 5.0 — These soils are said to be subacid and are formed in non-calcareous regions. They consist of many types of meadowland, upland woodland soils, marshland or former marshland soils lowland area soils often rich in organic matter and humus. Somewhat similar soils are familiar in the Western American coastal areas and other regions of high rainfall. They often overlay high water tables, are often rich in organic matter and frequently are gravelly or gritty. A wealth of lily species are native of these soils, some in association with rhododendrons and bamboos in the Japanese islands and mainland China. Species such as japonicum, speciosum and auratum thrive.

pH 5.0 to pH 4.0 — In this group are those which form peat bogs, rhododendron and ericaceous soils, woodlands where stands the pine, spruce, etc. dominate. Areas of upland peat or where rotting wood, bark and similar materials form the base. Occasionally sands overlying an acid sub-strata are of this group. Low, moist inland meadows and scrubland are in this very acid soil group where such species as occidentale, catesbaei and philadelphicum exist. Occasionally L. superbum is found on these soils.

Fallen rhododendron leaves, pine needles, etc. contribute greatly to soil acidity although rhododendrons are usually found growing in soils above the 4.5 mark.

pH below pH 4.0 — I don't believe any lily finds a home in soils having a pH value of less than 4.0, which is just as well because such soils would be difficult to duplicate in the garden.

To further simplify the facts: pH of 7.0 is neutral; however, for all practical purposes a much broader base is used in the garden. Thus, neutral soils are those ranging between 6.5 to 7.5 because the level of soil acidity or alkalinity is so low that it has no significant effect upon lily growth.

Calcareous Soils: Such soils contain limestone and/or dolomite in varying quantities and these were derived from the basic rocks through the natural process of weathering. Although they are the same chemically, there are two types of limestone, (1) a soft, chalky and easily weathered type and (2) a much harder rock which disintegrates but slowly and has considerably less influence on the alkalinity of the soil than has the chalky type. It could well be true that none of the lilies in existence today are true natives of calcareous soils. It is much better to describe them as being tolerant of lime, and even then are only tolerant of soils which are mildly alkaline. The following list of lilies represent the group which is tolerant of lime (pH 7.5 and higher) although all are quite at home in neutral soils; they are L. henryi, L. candidum, L. monadelphum, L. pyrenaicum, L. bulbiferum, L. hansonii and L. x testaceum, and L. szovitsianum, L. chalcedonicum, L. carniolicum, L. pomponium.

Acid Soils: These are also derived from the basic rock formations, granite being a typical example, and there are many others, of course. But the acidity of many soils is also brought about by other agents. As previously mentioned, areas beneath coniferous trees accumulate acid organic matter at the soil surface and which, by the action of rains, leaches the resulting acid humus deep into the soil below. Much of the soil's acidity arises from the minerals which form the soil; some sandstones are very acid. L. speciosum var. gloriosoides, one of the most beautiful of all lilies, grows wild in central China among acid sandstone. Other lilies native to acid soils (pH 5.0 to 6.5) are the species auratum, speciosum, japonicum, rubellum (and their hybrids), canadense, grayi, michiganense, superbum, leichtlinii, nepalense, medeoloides, and most of the Western American species. Lilies which demand very acid soils (pH 4.0 to 5.0) are L. catesbaei, L. philadelphicum and L. occidentale.

Neutral Soils: Soils of this group (between pH 6.5 and 7.5) are very important to lily growers. They are the medium for some of the most popular lilies grown throughout the world. The majority of our hybrid asiatics, aurelians and trumpets do well in neutral soils, although most can be grown equally successfully on soils having an even wider pH base, say pH 6.0 to 8.0. The true trumpets, more particularly those having a majority of centifolium genes in their make-up, will do somewhat better from pH 6.0 to 6.5. It has been stated quite often that the pink trumpets grow much better on soils which are slightly acid, but I have reason to doubt this: They do not thrive better although they do tend to have a somewhat better colour when the soil is on the acid rather than the alkaline side. Lilium martagon and many of its varieties are also natives of neutral soils while one or two forms can also be found on slightly alkaline soils. Many, many species are natives of these neutral soils.

Climate and Organic Matter: The organic and humus content of soils varies from as little as 1% to as high as 80%. Generally, upland soils are more mineralized and range from 1% to 8% organic matter while less well-drained soils are usually much richer in organic matter and humus than are the soils of the prairies and similar regions. Climate definitely influences the type and the amount of organic matter found in any soil. Furthermore, the character of the soil is determined by the type of vegetation native to the region. Under dry upland conditions, the native plants tend to be narrow-leaved and tough, while under more moist conditions a larger and more leafy type of vegetation prevails. These two types of vegetation break down and decompose in very different ways. The large, leafy plants yield a generous supply of organic matter while the coarse and more leathery plants yield a rather meagre and coarse type of organic matter. Thus the soils of coastal areas and other regions of high rainfall are usually much richer in organic matter than the dryer inlands soils of the American Middle West, the Siberian Steppes and similar regions throughout the world.

In coastal regions and the lands surrounding large bodies of water the precipitation rate is higher and the soil has a much higher moisture content: It also has a lower temperature because water has a cooling effect. Furthermore, such areas have a higher atmospheric humidity which in itself is a boon to plant growth. In Middle America much of the annual precipitation is in the form of snow; much is lost to plants because of run-off in early spring.

Most lily growers are aware that lilies are quite sensitive about the organic content of the soil and respond quickly when there is too little or too much. Don't try growing the asiatic hybrids in acid, highly organic mediums. At best the results will be poor. The species L. pumilum and L. cernuum are true natives of the dryer and more mineralized soils while the species L. rubellum and L. japonicum are very much at home in the rich organic soils, always moist and often wet, of Japan.

The organic matter of the soil, therefore, arises from the remains of previous generations of plants, insects, micro-organisms, and even animals. Organic matter is conveniently grouped into two divisions according to age. Some of it is as old as the soil itself while the remainder is newer and represents the residues of recently living organisms. The older material is properly called humus while the newer and less decomposed matter is referred to as organic material. This organic material is of the utmost importance to lily culture, consisting as it does of undecomposed roots, stalk stubble, fallen leaves, manure, peat moss, compost and other vegetable matter which has been incorporated in the soil. It keeps the soil open and porous, forms passages through which excess water can drain away and air can enter. It also prevents the soil's mineral matter from compacting and gives it a much greater water-holding capacity.

Soil Fertility: The fertility levels of soils in their natural state is largely due to the nutrients derived from the weathered rocks.

For instance, feldspar, a very common rock, yields potash; another rock common to Ontario is apatite which provides phosphates, But these original soils have become modified in many ways. Trees, shrubs, and plants send their roots deeply into the soil in search of water, nutrients and even trace elements. These are absorbed by the root hairs and transported upward to the leaves and there synthesized into carohydrates, proteins and other compounds. Ultimately these products are deposited on or very near the soil surface to once again become the nutrients for the next generation of plants or become an integral part of the soil and held in reserve. Thus the natural topsoil becomes richer in nutrients and organic matter after the shedding of leaves during every fall, with the death and decay of every plant, shrub and tree, and much of it has been brought to the surface from levels far below the ground. Unfortunately, this is not enough for the purpose of growing lilies and a supplement has to be provided. We will deal with this subject a little later.

One of the main problems which face all lily growers is ....what do we do with the only soil available to us in order to grow the lilies of our choice, and to the peak of perfection which, naturally is our aim? Ideally, a good basic soil would be a medium loam, fibrous and having good drainage, a fair amount of organic matter, and a pH value of between 6.0 and 7.5. Such a soil would grow a wide variety of lilies and other plants. In actual fact, any soil that will grow good vegetables will also grow lilies such as the hybrid asiatics, martagons, aurelians and trumpets to the same state of perfection as it will grow vegetables. A great number of the species lilies would also thrive in such soils - amabile, callosum, concolor, dauricum, davidii, the hollandicums, medeoloides, papilliferum, parryi, regale, sargentiae, tigrinum, and tsingtauense etc. For such groups as the orientals and Western Americans, however, considerable modification would be necessary: I do believe that most of our garden soils can be modified to meet the demands of these two groups.

In order to achieve optimum results the keen lily grower should make use of a simple soil-testing kit which will help to obtain an accurate soil pH value whenever necessary. The frequent testing of soils undergoing modification will undoubtedly enhance the chance of meeting the needs of the lilies more precisely. Having carried out a soil test the gardener will then have a good idea of what is necessary in order to bring the soil acidity or alkalinity to the required level - from pH 5.0 to 6.0 for the speciosums, 5.5 to 6.0 for many of the Western American species such as Kelloggii, 6.0 to 7.0 for pardalinum, and so on.

It is often believed that leaf-mold, compost, farm manure etc., are acidifying materials, but this is not so. Most are neutral or only slightly acid. Peat moss can usually be depended upon to be strongly acid although it does vary in acidity from source to source. Upland peat found beneath pines is usually strongly acid. Other acidifying materials are well-rotted sawdust and wood, and particularly crumbly-rotten tree bark; many tree barks are rich in tannin which is an excellent acidifying substance. Where such materials are used they should where necessary, be first composted and it is a good idea to add a little nitrogen fertilizer which is a nutrient for the micro-organisms which break down the materials. It should be also kept reasonably moist at all times - moist, not wet. From a purely practical viewpoint it is evident that these materials cannot be used on a large scale; availability is the problem. However, where just a few bulbs are to be grown in the border it should not be difficult to acquire and use such materials to advantage.

Peat Moss: Where a strongly acid soil is required for, say, the orientals, and a considerable quantity of peat moss is to be used it is always wise to mix coarse sand or small gravel with the peat to ensure adequate drainage. Peat moss can hold up to ten times its weight of water and during periods of wet weather an unfavorable environment is created for lily bulbs.

The soggy wetness encourages basal rot; it forces the "sweetening" air out of the soil, thus creating a most unsuitable medium for bulbs, roots and soil micro-organisms. In other words, the delicate balance of life within the soil is destroyed, often with disastrous effects. The air space within the soil is closely tied to the water supply; the only space available for air is that portion of the pore space not filled with water. Hence, soils which are likely to become water-logged need an abundant supply of drainage materials to keep them open and sweet. This is particularly true where much peat moss is used; it is also true of clay soils. Good soil aeration favours the development of a large root system and bulb size, as well as vigorous growth and large leaves. Root respiration (root breathing) is said to be closely linked to the intake of plant nutrients.

The correct degree of soil acidity is not very difficult to achieve. An approximate pH reading can be had through using the right amount of peat moss or whatever acidifying materials are used. Peat moss, of course, is the most convenient material for most lily growers. Once this is done a further and more precise adjustment can be made through the use of acidifying sulphates such as those of iron and aluminum - used for the bluing of hydrangeas. To illustrate this secondary modification, and assuming a pH of 6.0 has been achieved through the use of peat moss, a lower value of, say, 5.5 can easily be had by using a small quantity of aluminum sulphate. This treatment will quickly cause the soil to respond. Sulphates should only be used for minor adjustments; the major adjustments should be made through the use of acidifying organic matter. Upward adjustment to the pH value - say 6.0 to 6.5 or 7.0 - can quite easily be made through the use of lime in the form of ground limestone (carbonate), burned lime (oxide) or the hydrate (OH). Where the oxide or the hydrate is used it is wise to leave the bed unplanted for some time until the lime "bite" has gone and no burning or root damage will occur.

Thus, for better and more accurate results lily beds can be adjusted in two stages, (1) by the bulk use of organic matter which has acidifying qualities, and (2) the final and smaller sulphate correction.

Composts: The use of composted materials has indeed proved to be a boon and is invaluable to the lily grower. Unfortunately, we can seldom make enough to meet our needs. A compost pile is generally made of vegetable matter, usually weeds, grass clippings, the tops of garden perennials, leaves etc. Composts such as this should be regarded as being neutral or only very slightly acid. The nutrient level is rather low, although where quantities of kitchen waste are incorporated in the compost, the nutrient level can be higher because such waste often contains animal matter. The art of composting is too well known to be dealt with here, however, I do like to fork it into the lily beds while it is still in a partial state of decomposition and still maintains some of its original structure. I believe this method ensures better soil aeration, improved drainage and a much better environment for the soil micro-organisms. The ultimate effect, however, is the improvement of the soil's texture as well as its moisture-holding capacity.

Leaf Mold: Leaves which are treated in the same manner as the above composts have much the same qualities. Again, it is preferable to use the partially decayed materials. Leaf mold is not easy to obtain these days, but an excellent source is any of the deciduous woodlots which dot the countryside. I often obtain leaf mold in this way for special treatments. Formed as a deep mat below an overhead canopy of leaves and branches which shield it from the hot sun and also prevents undue evaporation of moisture, it is a wealth of leafy organic matter in various stages of decay and of a nature similar to that formed in coastal regions. It is ideal for digging in to the lily beds and is particularly good for lilies such as the auratums and the western Americans. Another good source of a similar type of material is the beds of creeks and rivers.

During the summer months when the water is at a low point there can be seen deposits of rich black organic soil formed from decayed vegetation and which for most of the year is covered with water. It is somewhat comparable to the soils of woodlots and coastal areas and can be used for lilies native to such soils. At the bottom of my own garden is a small creek which, naturally, swells each spring. On both sides of the creek has been deposited deep beds of black, organic-rich soil. I have used this soil to good advantage from time to time. After digging it out of the beds it is left in a pile to dry. Later, when completely dry, it is broken down to a fine soil and then mixed with the garden soil where the lilies are to be planted. I used this soil some years ago when planting a few bulbs of L. parryi, a very difficult subject to grow in this part of the world. But each year these bulbs thrive beautifully - flowering and producing fat seed pods every year without fail. This particular black soil has also proved to be beneficial for the growing of orientals in the greenhouse.

Farmyard Manure: Manure is still the commonest form of organic matter used by gardeners everywhere, yet many lily growers persistently refuse to use it under any circumstances. I have never agreed with this viewpoint and use it whenever possible. Prejudice is often very difficult to overcome; however, my own experiences indicate that if farmyard manure is used properly it is indeed a most valuable source of both organic matter and nutrients. In front of my home is a rose bed and each year it receives a top-dressing of four or more inches of manure. Toward the back of this bed--but still growing among the roses--are a number of L. henryi bulbs. This species is lime tolerant yet in spite of the manure it produces flower heads on stems to eight feet tall.

The procedure of applying manure to lily beds is as follows: The manure remains in a pile for at least a year during which time it is turned once or twice to provide air for the micro-organisms and thus assist decomposition.

At the end of one year, or whenever needed thereafter, the manure is used as a mulch on the lily beds. At the end of this second year much or most of it has broken down completely and has a soil-like texture. It is then carefully forked into the soil among the lilies. Experience indicates that stem-rooting lilies such as the asiatics benefit considerably while it is in the form of a mulch, not only from the shade and hence the soil-cooling effects but also from the nutrients which filter down to the stem-roots following each rain. Non-stem-rooting lilies, which feed by way of the basal roots such as L. candidum and most of the European species, do not appear to benefit as much from the mulch; only when it is finally forked into the soil does any benefit become apparent. Another way is to apply one year old manure to beds which have been cleared of lilies. The manure is forked in evenly to a depth of ten inches or more, following which the beds are left fallow or planted to vegetables during the coming year.

<u>The Subsoil:</u> The lower portion of the soil differs so much from the surface layer, or topsoil, that it is given another name - the subsoil. The difference is caused by the fact that neither plant or animal life has exerted any great effect on it, and the subsoil contains very little more than the original mineral matter. It contains little humus and hence the physical properties leave much to be desired. The subsoil is considerably less fertile than the topsoil and is frequently compacted. Where the topsoil is relatively shallow the lily grower will find it necessary to bring some of this subsoil into cultivation by deep digging and forking, and by incorporating ample organic matter and plant nutrients into it. By improving the subsoil a greater depth of fertile soil is made available to the lilies and the basal roots have a deeper medium in which to grow. Furthermore, the additional organic matter in the subsoil provides a more adequate moisture reservoir. Naturally the pH value of this improved lower level should be adjusted so that it corresponds to that of the topsoil.

The subsoil becomes much more important to those lily growers who wish to master the art of growing species such as L. polyphyllum, the bulbs of which can be found at depths of two feet and more in their native habitat. There are, in fact, many species which demand greater depths than the usual four or five inches required by the asiatic hybrids and other lily groups popular in gardens today.

Clay Soils: Clay belongs to a class of substances called colloids, a word which means like glue. In any soil mixture it is such a dominating substance that even a small quantity impresses its properties on a large bulk of sand or silt. A soil having even fifteen percent of clay has a greasy or slippery feel and can be difficult to cultivate. Because of the extremely small size of the clay particles it packs tightly, the air/water pores are minute, the consequence of which is that water movement is impeded and such soils can quickly become water-logged. Furthermore, clays hold water so tightly that plants cannot readily extract and use it and may wilt in spite of the fact that sufficient water for their needs may be present.

Soils which have a considerable clay content are poor lily soils. In the early spring when the clay soil is quite wet the young lily shoots may fail to emerge; they just cannot push their way through the tough, greasy medium. Even when they do, growth is often stunted. Clay soils are cold soils and do not warm to the spring sun as quickly as the lighter soils. However, such soils can be considerably modified. The first step should be carried out in early fall by applying a liberal amount of lime, then forking it in to a depth of about one foot or even more, making sure it is thoroughly incorporated into the soil evenly. Nearing the time of freeze-up the soil should again be forked to aerate it and also effect a more complete mixing of lime and soil. The following spring an ample supply of partly rotted organic matter, compost, leaves, strawy stable manure, or almost anything of this nature should be dug in.

An occasional aeration, by forking can be beneficial during the coming months. If the soil is kept moist during this period it will greatly assist in building a truly "living" medium. The soil should be ready to receive lily bulbs during the coming fall. Where the gardener has a choice, and he rarely has, manure from horse stables should be used rather than cattle manure. The manure from horse stables is said to be a "warm" manure, heating up quickly and decomposing quickly to form a lighter soil. Its very nature lends itself to use on a clay soil much better than cattle manure which is heavy and inclined to impart its heavy qualities to the soil, which is something to avoid with clay soils. Cattle manure which is well-aged and decomposed should be used for the lighter and sandier soils, the end result being a heavier soil with improved texture. After the lime has taken effect the calcium clay forms "crumbs" which remain stable in the presence of water. This granular structure makes for better tilth and drainage while the added organic matter creates the necessary soil structure, moisture-holding capacity, as well as adding some nutrients for the growing of lilies. Manures vary considerably in their nutrient content; those coming from animals fed considerable amounts of concentrates are much richer in N P K than those coming from grass-fed animals. However, this should not greatly influence lily growers because after the manure has been stock-piled for at least a year it has lost some of it nutrients and particularly the nitrogenous portion, thus making it much more acceptable for lily growing.

<u>Loams:</u> There are many types of loams although they are usually categorized as being heavy, medium, or light. They are soils which are best defined as not being as heavy as clay and not as light as sand. It is probable that most garden soils are loams of one type or another. Usually they contain not more than 15% of clay and not more than 20% of sand and are made up mainly of intermediate materials.

Loams are by far the most fertile of our soils; the medium type being particularly valuable for those groups of lilies which are commonly grown in gardens. Heavy loams - those containing much clay - may be modified for lilies in much the same way as the clay soils, which has already been described. The light or sandy loams, however, require special treatment.

Light, Sandy Loams: Sandy soils are very porous and readily allow the passage of water. Hence, they suffer from drought during periods of dry weather. In its almost unimpeded passage through the soil the water carries with it much of the soluble matter including the fertilizer nutrients. Therefore instead of applying the usual amount of fertilizer in early spring it should be given in small but frequent doses so that it is available for the lilies throughout the season of active growth and little is lost through leaching. To correct this soil porosity it is necessary to add ample organic matter to soak up and hold the water in the topsoil. It will also prevent the loss of the nutrients. Even then, and because of this porosity and hence the rapid oxidation of the organic matter, it is advisable to apply some organic material each year. Sandy soils also require regular but small applications of lime because this material also leaches out of the soil quite rapidly. This is particularly true where lilies requiring a soil pH of 6.5 or more are to be grown.

Sandy soils should be regarded as good soils by lily growers. They never become water-logged in wet weather unless there is a clay pan beneath. They are early soils, are easily modified, can take large amounts of organic matter, the pH value can easily be adjusted up or down, while they are so easily worked that a considerable depth of soil can be cultivated, thus ensuring excellent root systems. Furthermore, basal rot is less prevalent than on heavier soil types while the size and quality of the bulbs produced on these soils is excellent.

Soil Moisture: The water requirements of lilies vary considerably. L. philadelphicum, for instance, grows on dry, gravelly, almost barren soils; in fact, I have seen it growing and flowering profusely in rocky, parched soils in which even the native grasses could scarcely find a roothold. On the other hand its close relative L. catesbaei demands a moist, almost swampy roothold. The Western Americans, evolved in coastal regions with fairly high rainfall, require more moisture than do the hybrid asiatics. So do the orientals which were evolved under conditions of high rainfall during the early growing period. On the other hand L. pumilum and L. cernuum delight in the dryer and more mineralized soils. Some species, their varieties and hybrids, of course, require soils intermediate in their water-holding capacity. The experienced lily grower will recognize this and attempt to meet this most basic requirement. Soil moisture comes from three sources, snow, rain and supplemental irrigation. Snow forms a non-conducting blanket for the soil and prevents the temperature from falling as low as it otherwise would. Lilies benefit considerably from a snow cover because the bulbs and basal roots are well protected from excessive cold; the surrounding soil is also protected from the drying winter winds. When cutting down the lily plants in the fall I find it advantageous to leave four or five inches of stalk stubble attached to the bulb. This assists in holding the snow over the bulb. This becomes very obvious when there are several stubs arising from a clump of lilies.

Water is held by physical forces in the soil pores. Whenever there is an excess it moves downward through the subsoil, finally entering the water table. Lily plants take considerable quantities of water from the soil, especially in the spring when growing vigorously. Water not only dissolves the nutrients, it also cools the soil, and lilies revel in a cool root-run. Water also cools the plant tissues during periods of hot weather as it passes through the root hairs, through the stem and on to the leaves where it makes its exit into the atmosphere through the stoma - after the nutrients have been removed, of course.

This process is known as transpiration. Occasionally during periods of hot, dry weather the leaves and stem tips wilt and this can cause serious damage to the tissues. It occurs because the lily plant is transpiring or giving off moisture at a faster rate than the roots can absorb it from the soil; in other words, the root system is not sufficiently developed to supply all the necessary water, or else the soil moisture content is too low. Both of these conditions can largely be overcome by sound cultural practices such as ensuring the soil has a good tilth, ample organic matter which will hold moisture for a considerable period of time, as well as the frequent hoeing of the soil. A layer or mulch of fine soil keeps it somewhat cooler and also helps to prevent the loss of moisture through evaporation. The fleshy lily bulb, too, acts as a water reservoir during periods of drought. Although it does help, its usefulness is definitely limited.

Supplemental Irrigation: Irrigation to supplement soil moisture may occasionally be necessary, particularly where the soil tends to be sandy. Most lilies grown in gardens today dislike wet soils. A properly balanced lily soil -- balanced for organic matter, humus, drainage materials etc., should not require irrigation except possibly during periods of prolonged drought. For all practical purposes it must be assumed that the lily soils of most gardens are somewhat less than ideal and are in the process of modification. Hence, irrigation in the form of a drench or overhead sprinkler system is carried out. A soil drench is excellent - providing the soil is deep, there is no soil compaction, and the topsoil is well-drained. Soils having much clay in their composition are often poorly drained and a soil drench should not be used. Clay-type soils, following a drench, are likely to bake and crack, a condition totally undesirable for lilies. Overhead irrigation is also good providing it is maintained long enough for the water to penetrate to the deepest basal roots. But no matter which method is used precautions should be taken against infections of botrytis and basal rot. A good spray program using Benlate should suffice.

Watering is unnecessary after the flowering period is over. The lilies should be allowed to move toward the ripening period without further supplemental irrigation. Where cross-pollinations have been made and the pods have begun to swell there is little to fear from dry soils. Lily plants, and for that matter plants in general, need water least when they are making seeds. The finest seed crops, both garden and farm, come from the dryer areas of the world.

Drainage: Where drainage is a problem it may be corrected by raising the lily beds. The soil can be removed from the dividing pathways and placed on the beds. Where only two or three bulbs of a particular lily are to be grown in the border, and such lilies are of a type which is sensitive to basal rot, a simple method is to fork the site deeply then press the base of each bulb into the soil about one inch deep, and no more. Following this a specially prepared soil mixture is placed over the bulbs in the form of a mound and to a depth of five or six inches. Each fall this soil can be removed and replaced by a fresh mixture. Not only does this method provide good drainage but it has consistently proved to be excellent for producing exhibition lilies.

Fertilizers: Most lily growers use fertilizers, and for two reasons, (1) to produce a soil medium having sufficient nutrients to produce quality specimens, and (2) to maintain this high fertility by annually replacing those nutrients removed from the soil by the lily plants. In a treatise such as this it is impossible to lay down guidelines for fertilizer use. We all have different soils with differing fertility levels; some soil types demand more fertilizers than do others. A soil analysis, of course, is by far the best method of ascertaining the kind and quantity of fertilizer to use. Experienced lily growers often determine fertility levels by the growth and health of their lilies. It is always wise to use fertilizers with the lower fertilizer (N P K) numbers and which are formulated for garden use.

These are slow-acting and ideal for lilies. Some fertilizers are designed to "boost" growth and are fast-acting and therefore unsuitable for lilies because they often cause root damage. Such fertilizers are often used by farmers for crops such as corn. Furthermore, it is wise to avoid fertilizers with high N P K numbers because they can create application problems for the amateur gardener.

Where no soil analysis is undertaken slow-acting fertilizers such as 5.10.10, 7.7.7, or 10.10.10 can be used effectively. The usually accepted amount of one handful per square yard is reasonable. Most lily authorities advocate that it be applied in early spring, and there is nothing wrong with this. My own method, however, is to apply two-thirds of this amount when the lilies are six to ten inches high, the remaining one-third being "scratched" into the soil in late fall -- as close to freeze-up as possible and when all growth has ceased. This portion is held tightly in the soil throughout the winter, becoming available to the plants at the first thaw which, incidentally, is when root growth begins. Hence, a supply of nutrients is available at the most sensitive period of lily growth. This method has proved to be very effective for me.

Except for this particular application, when the dormant period has arrived, the use of fertilizers should cease about mid-July, no matter what kind of program is used. Fertilizers stimulate growth and this is undesirable after the flowering stage has been reached. Lilies should be allowed to drift slowly toward bulb maturity and stem die-back without any stimulus whatsoever. It is further suggested that for soils which have a low organic content a 5.10.10 fertilizer be used, but soils which have ample organic matter - and particularly those which have had recent applications -- a fertilizer having a higher nitrogen content should be given. This additional nitrogen will be food for the micro-organisms, causing them to multiply rapidly and thereby bring about a more rapid breakdown of the organic matter.

Nitrogen applied in moderation is important to lily growth; the phosphates and potash, however, are extremely important to the production of bulbs. Each year the old bulbs die and are replaced by new ones and the nutrients phosphate and potash play a major role in their formation.