SOME ASPECTS OF IRRIGATED GRASSLAND.

R. B. Tennent, Fields Superintendent, Dept. of Agriculture, Dunedin.

New Zealand has a world wide reputation for being an ideal grass country on account of the benign conditionsof its soil and climate. The average visitor to this Dominion leaves with the impression that highly productive pastures grow with little effort or expense to the farmer over most parts of the country, That such a wide generalisation is totally erroneous needs no emphasis, there being in point of fact only a limited area in New Zealand which can stand up to the growing reputation which is often accorded to the country as a whole. Those familiar with conditions know full well that only a tithe of the country is well grassed and that large areas remain to be successfully dealt with, As an example of this it is interesting to note that of the 67 million acres of the Dominion, 43 million acres are occupied and of this latter area over 24 million acres are classified as unimproved lands. This by no stretch of the imagination means that the 19 million acres of improved land are in a high state of productivity, Of this 19 million acres, 17 millions are sown to grass, some good, some indifferent, and a large proportion of inferior quality. Broadly speaking it can be assumed that at least 50% of the good pastures receive topdressing, and if this surmise is correct and recognising the fact that 2½ million acres received topdressing either with fertilisers or lime last season, it can then be assumed that of the 17 million acres in grass only 5 million acres in all probability are what might be termed first class pasture. The great problem confronting agriculturalists is the improvement of the existing grass areas in the Dominion, and the best methods of bringing about a reduction in the area of unimproved occupied lands. Comparatively speaking, there is little'more to be learnt concerning the improvement of what may be termed good pastures, and more attention should rightly be focussed on how to deal effectively with the sterile areas of the Dominion whether it be the gum and pumice lands of the North or the pakihi and semi-arid areas of the South, In approaching the problem of the reclamation of these areas the investigator is at once faced with the fundamental question of determining what are the limiting factors inhibiting grass growth, and it is only the solving of this question in a practical manner that will lead to the successful bringing in of hitherto unproductive areas.

So far as the semi-arid areas of the South are concerned, and in this respect one refers more particularly to the 500,000 acres Of potentially irrigable land in Central Otago; the chief limiting factor to grass growth is'lack of moisture. With a rainfall averaging from 11 to 18inches per annum well distributed over each month of the year, coupled with the fact that high summer temperatures are invariably experienced, it can at once be realised that nature has placed Central Otago at a decided disadvantage, compared with other more humid portions of the Dominion, The land in the valleys is sparsely covered with scab weed (raoulia), hairgrass, poa Maniototo and Sorrel, whilst the hills in the main are in a denuded condition with here and there sparse growth of tussock. Fortunately, however, the soil in the valleys is exceptionally good, composed largely of mica-schist silt overlying gravels, thus affording almost ideal conditions for irrigation without any serious fear of waterlogging.

The most recent figures disclose the fact that approximately 64,000 acres are irrigated in Central Otago, and further extensions are at present in hand to embrace additional large areas. Of this acreage 3000 acres are in lucerne, mainly used for winter feed, and 1000 acres are devoted to orcharding. Altogether, it can be assumed, allowing for land not yet dealt with, that approximately 55,000 acres are in irrigated pasture, and a consideration of some of the vital factors relating to the establishment, care and management of such, will at once disclose the fact that grass growing under irrigation presents some complex problems.

The question which immediately confronts the irrigation farmer who proposes to lay down a permanent pasture is the seed mixture which should be used and so far as experience has shown there can be no question that the right type of perennial ryegrass and white clover stands out preeminently. On the Galloway Experimental Farm the most productive pasture was an old permanent ryegrass-white clover field, sown down some thirty years ago with what obviously must have been a 'good type of Southern ryegrass. The response of this Pasture to irrigation has been astonishing, and despite the severe treatment which it has received having been for a long time used as the ram paddock for Galloway Station, it today retains its pristine glory and is a striking testimony to the importance of sowing the right strain of ryegrass. Cocksfoot has failed entirely to prove its suitability as an irrigated grass, being low in productive ability, and having a much shorter period of growth than ryegrass. When heavily grazed by sheep or cattle, even with copious irrigation, it is slow to recover, and compares most unfavourably with ryegrass in this respect, Poa pratensis, which is sometimes included in permanent pasture in the more humid areas, is a pest with the irrigation farmer and should certainly not be included in any mixture, Under irrigation it grows most aggressively, choking ditches, invading lucerne fields and orchards, and ultimately spoiling good 'pastures by making them sod bound, Clovers respond to irrigation admirably, and the inclusion of white and alsike clover in a permanent pasture mixture is practised.

As the bulk of the pastures are sown on the slopes under the irrigation races, the heavier flats being usually reserved for lucerne growing or cropping, the preparation of a suitable seed bed is of importance, Owing to the scanty natural growth, there is no need to plough deeply, in fact such a practice would prove disastrous, inasmuch that erosion of the loosened soil would take place immediately water was applied, The practice which has evolved is to thoroughly disc the slopes, after having softened the soil by a preliminary application of water, the seed then being sown and harrowed in, This method of procedure invariably brings about the establishment of a good pasture, without unduly loosening the soil, and allows for liberal applications of water immediately the seed has germinated, Owing to the severity of the winter, spring sowing is the invariable practice,

In the irrigation of grass either of two main systems, or their modification can be adopted, depending upon the grade of the land. Where the pasture is on a fairly steep grade, contour irrigation should be adopted. This system is the only one which can be recommended for very steep land, and is quite efficient for any slopes of 3 ft. per chain or steeper, It can and is used on slopes with a fall of less than 3 ft. to the chain, but becomesuneconomical in duty of water and labour costs as against other methods. In this system the distributory ditches or furrows follow very nearly the contours of the land, and although it has the inconvenience of many furrows placed irregularly about the field, it has to be borne in mind that the steep slopes for which it is recommended are usually capable Of being used only for pasture purposes, consequently a multiplicity of shallow distributories is of no great moment.

Where the land is flat the Border-dyke system should unquestionably be used for irrigating the crops. * Although this method calls for considerable expenditure in the preparation of the land, when once laid down it becomes a permanent system, considerably reducing the amount of labour in irrigating the crops, and by its use one can ascertain precisely what depth of water is being applied, a matter of first importance, particularly where the supply is restricted.

* For full particulars in regard to systems of irrigation refer to Department of Agriculture's Bulletin No. 120 - "Irrigation Practice for Central Otago Conditions" by R. B. Tennent and J. R. Marks, 1930.

The frequency with which a pasture requires irrigation is of vital moment. Obviously the ideal to be aimed at is to supply the stock with a continuous growth of succulent feed throughout the growing season, and to do this the irrigator has to be an adept in the handling of the water allocated to him. Under the irrigation schemes operated by the Government, the quantity allotted to farmers varies from 24" to 36" in depth for each acre of irrigable land, according to the class of land upon which he is situate. Consequently he is wise who regulates his irrigations in such a manner as not to be left in the unhappy position of being short in the fall of the season. As can be appreciated the duty of water, will vary considerably with the type of soil and crops growing thereon,

By "duty of water" is meant the total amount Of water necessary to obtain the highest production from the crop to which it is applied. It therefore expresses the relation between a given quantity of water and the area it serves. The duty of water is therefore high or low according as a given quantity successfully irrigates a large or small area. There is no problem of such-great importance as that dealing with the volume of water required to maintain growth successfully on pastures, and the utilisation of such water in the most advantageous and economical manner. The fullest utilisatidn of water when applied to Pastures naturally occurs when every drop is utilised by the plants, leaving none to be lost by percolation or evaporation, The practical attainment of such an ideal is of' course impossible, otherwise a limited rainfall and infrequent irrigations would suffice to ensure productive pastures.

It is obvious that different soil types have varying water holding capacities, for example a loose sandy soil is not so retentive of moisture as one of a loamy nature, The majority of soils in Central Otago devoted to pasture production, are of a light, free, open character, with a low organic content, and it will be recognised that as such they have a limited water-holding capacity. Consequently when once a sufficient amount of mater has been applied to saturate those light soils, any further applications must result in the loss of water by percolation, thus reducing the effective work which that water might reasonably be expected to perform.

In applying water to pastures frequent light applications will give most profitable results. There are large areas of grass situate on soils with a water holding capacity of 3 inches, but the irrigators of these areas instead of dividing their yearly supply of 24 inches into eight irrigations of 3 inches each, endeavour to reduce the number of irrigations to four, applying approximately six inches at a time, only to find that the water supply is insufficient for maximum grass growth. The result of such practice in the past has led to the general belief among settlers that the Government allocation of water is too niggardly, and considerable pressure has been brought to bear with a view to having the supply increased. Actually in such cases the trouble is that in each irrigation the soil has been over saturated by at least three inches of water, which. is lost by percolation,

Few pastures require much more water in the initial stages of irrigation, as the soil is then receptive and becomes easily saturated. As the pasture becomes established sealing of the soil takes place , and the organic content is gradually increased thus considerably lessening the water requirement and so increasing the duty of water. In this respect pastures play a most important part in the building up of the organic or humus content of the light soils, thus gradually evolving conditions which very materially lessen the necessity for such frequent irrigations as are required in the early stages of growth,

A condition which faces the farmer of irrigated lands on such areas as Galloway, Springvale and Manuherikia, is the absence of

humus or organic matter in the soil. To a considerable extent, the very characteristics that make the arid land so desirable when irrigated are necessarily inseparable from their lack of humus at the start, and therefore the supplying of hwnus, should be treated as one of the steps in preparation Of arid land - exactly like ***supplying an*** irrigation system, Vegetation, through lack of moisture has ever been sparse on these lands and naturally before the farmer can expect any considerable yield, he must supply the deficiency when his land "comes under the ditch". The establishment and stocking of a pasture is one of the best means of doing so.

Where pastures are intended to be sown on the heavier types of alluvial flats, there is unfortunately a regrettable disregard of the importance of autumn ploughing. Too much stress cannot be laid on this procedure, particularly for the irrigation farmer. Deep tillage in the autumn enables the soil to absorb moisture from the winter snows and frosts in a quantity not possible in any other way, and it is an undeniable fact that such land will require one third less water during the first season than land not so prepared. In other words a pasture will rapidly establish and produce particularly well on $1\frac{1}{2}$ acre feet of water, whereas if the land is 'not so prepared $2\frac{1}{2}$ acre feet will probably be required.

On certain limited areas in Central Otago farmers meet with difficulty in establishing pastures, and investigation shows that the cause of failure is sometimes due to the presence of either black or white alkali. These injurious salts are chiefly the chlorides, carbonates and sulphates of sodium, or may occasionally prove to be the chlorides or sulphates of magnesium, potassium or other salts. The accumulation of these salts is slow and insidious, and one ***often*** witnesses pastures slowly deteriorating as the alkali gradually increases. When large quantities of water are applied to the ground, a considerable proportion of these salts are turned into solution. Excessive evaporation follows excessive watering and the dissolved salts are by capillarity brought to the surface of the soil where they remain. In 1926 preliminary investigations conducted on Galloway Flat showed that contrary to expectations, on those areas upon which pasture growth - and particularly clover growth - was inhibited, the toxic constituents were largely sodium chloride and sodium sulphate, there being a negligible quantity of carbonate in evidence. In no case was the carbonate present in excess of 330 parts per million which is well below the toxic limit of 3,000 - 4,000 parts given by Guthrie and Helms (Ag. Gaz. N.S.W., 14, 1903). The Sulphate radical was found to be present in fairly large quantities in some cases being as high as -13,000 parts per million, The most surprising result was the prevalence of sodium chloride, amounting in some cases to as much as 30,000 parts per million, the toxic limit of this being 2000 parts per million.

While the toxicity varies according to the proportion of moisture and organic content of the soil, as has always been mentioned these two factors are generally speaking low in Central Otago, hence chloride toxicity will naturally be severe even in the presence of much smaller quantities than those indicated above. In the case of 2-l soils tested twelve gave results showing the amount of chloride and sulphate to be greater than 7,000 parts per million. It is obvious therefore that attention has to be directed towards correcting this soil condition prior to or during the establishment of pasture, The use of gypsum ($CaSo_4$) has been tried out with excellent results as a means of overcoming the bad effects of sodium carbonate or'black alkali, whilst indifferent results have been obtained from the use of Lime ($CaCo_3$). In the case of Sodium Chloride, where such is present to an injurious extent harrowing and heavily irrigating the field invariably results in temporarily overcoming the difficulty, the salts being dissolved and carried off in drainage.

The use of fertilisers for topdressing irrigated pastures is not as yet a common practice with irrigators, but the experiments conducted by the Department at Galloway and elsewhere, Point conclusively to the fact that production can be very materially increased by their use, and that the amount of water required for irrigation will be considerably lessened if this practice be adopted. It is to be borne in mind that one of the main functions of water is to supply plants with food in solution, consequently it follows that if the concentration of soluble Plant food contained in the water is high, less water will be necessary. In other mords a good strong solution would have a higher duty and go further than a weaker *one.* No concentrated campaign has as yet been launched in Central Otago with a view to advocating the use of fertilisers on pastures, as the bulk of the land in its present state is of high fertility. Fir. B. C. Aston writing in the New Zealand Journal of Agriculture for June 1923 gives it as his opinion that "the fertility of the mica-schist soils of Otago is due *not* to lime or Potash or to the total amount of phosphoric acid they contain, but to the comparatively large amount of available phosphoric acid present - a point of great theoretical and practical importance." The same writer points out that this amount of available phosphoric acid would probably equal a dressing of 8 cwt. to 1 6 cwt. of phosphoric acid per acre, which would take from 2½ tons to 5 tons of Superphosphate to supply.

The time is rapidly approaching, however, when topdressing and liming of irrigated pastures will have to be carried out as a routine Practice, Particularly with a view to encouraging early spring and late autumn growth of grass, and as already intimated sufficient evidence has been secured to point conclusively' to the fact that this result can be attained.

Broadly speaking there are two main groups of irrigation farmers, the larger being dependent on the returns obtained wholly from irrigated land, whilst the second group, the runholders, have only a portion of their properties under irrigation, this being used mainly for the Production of their winter feed, enabling them to winter a greater number of sheep than would otherwise be the case. The benefits of irrigation to the runholder are considerable, and no type of irrigation farming has proved more valuable when viewed in regard to its ability to increase the carrying capacity of run country. On the other hand, where a farmer is on wholly irrigated land, he has to utilise his pastures either by the grazing of sheep or cows. Consideration has been given to the raising of sheep on such farms and Probably for a few years this can be successfully carried out, a single person earning more for his labour from sheep than he would from cows, inasmuch that it is easier and cheaper for him to handle at least twice as large an area as a dairy farmer, from the fact that the provision of winter feed does not present so much difficulty, and the actual irrigation of his Pastures need not be carried out in such a thorough manner as is required when dairy farming is resorted to. The chief and very serious drawback to sheep farming on a wholly irrigated farm however, is that the animals become so badly affected with foot-rot when confined solely to irrigated pastures, that before long it become a practical impossibility to work the farm intensively with this class of stock. Dairy farming offers great possibilities in the development of irrigated country, largely on account of the fact that cows in general give a higher per acre return than any other class of stock on irrigated country, and intensive stocking by cows of irrigated pasture is possible. During the season 1928-29 for example, Galloway Experimental Farm with an area of 89 acres of irrigated land successfully carried 91 head of dairy stock of which 56 head were milking cows.

The Proper control and sensible regulation of grass growth under such intensive stocking is of great moment. Much has been heard in recent years in regard to the advantages of rotational grazing

and whatever the merits of such a system may be under humid conditions there can be no question that the subdivision of an irrigated farm into small areas, is of great benefit. The value of changing stock from one field to another, and thus allowing each field spells in rotation cannot be over emphasised. Nothing will more quickly ruin an irrigated pasture than continuous grazing and the only way by which this can be overcome is by sub-division. This allows the animals to be changed from one field to another whilst irrigation is being carried out, and also allows for frequent harrowing of the pastures to conserve moisture. It should never be necessary to irrigate a pasture while the animals are grazing upon it since they would considerably damage it by cutting up the turf with their feet. For these and other reasons the practice of alternating from one pasture to another ensures fresher, better, and far more abundant feed.

In conclusion it is to be pointed out that there are large areas in New Zealand, particularly in Canterbury, where water would undoubtedly mean much in the successful establishment and maintenance of pastures, and one feels that at no distant date large tracts of poorly productive land will ultimately be converted into luxuriant pastures.

Although a comparatively new science in the Dominion, the art of irrigation dates back to the beginning of written history. A great succession of civilisations have flourished on irrigated soils. Irrigation therefore is no modern discovery. In ancient days the use of water on irrigated lands was not based upon scientific principles but rested merely upon regulations, some of which were wholly contrary to the best modern knowledge.

Those who made the first discoveries and applications, fundamental in modern agricultural practice, lived and laboured under a humid sky, consequently no direct studies of irrigation were made by these early investigators. It is only within recent years that serious scientific study of irrigation has been made, and only in the last decade has our best knowledge of the principles underlying the art of irrigation been developed and assembled.

One of the most regrettable features of our irrigation schemes in the Dominion is the fact that although hundreds of thousands have been and still are being spent in the erection of magnificent irrigation works, practically nothing is being done to determine the best manner of utilising the water when it is made available to the land. No matter how well constructed an irrigation system might be from an engineering view-point, if the farmer under the race cannot successfully utilise the water, the scheme becomes a failure, and the capital expenditure is a bad investment. The policy of closing the only investigational area in Central Otago, and the reduction of all expenditure on irrigation research on the grounds of economic necessity, is a retrograde step, and it is difficult to appreciate the logic which agrees to the spending of large sums of money for the erection of irrigation structures, yet ignores the vital necessity of expending a limited sum to see that the best use is made by farmers of the water brought on to their farms.

Much experimentation is yet needed before we understand properly and fully appreciate the relationships existing between water, soils and crops, but in the few brief observations just outlined it is hoped that sufficient has been said to indicate to the members of this Conference that there awaits a wide field for investigational activity in the study of irrigation farming.
