MAXIMUM ECONOMIC YIELDS FOR SMALL GRAINS

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Summary

During the 1984 Congress of the winter grain production committee of the Free State Agricultural Union, the Chief Director Agriculture, of the SA Department of Agriculture, Prof S A Hulme stressed the point that economic efficiency is the most important factor for a wheat farmer's success. This remark sets the tone for the paper under discussion.

The concept of maximum economic yields (MEY) or optimalization of yields has resulted in a different approach to the production of crops. Where previously single links of the chain were strengthened, the new concept places main emphasis on integrated production systems with multi-disciplinary co-operation.

In the United States and in Europe (including England) the realization that only combined effort can result in optimum yields gained momentum in the late sixties.

Systems have been developed, rejected, changed and finally accepted with the proviso that different conditions require different systems.

Dilz (et al 1982) gives a clear and concise example of the economic results of different systems of wheat production which are used in the Netherlands, Belgium and West Germany. They emphasize that any system should be flexible so that varying conditions can be accommodated. In the same article the authors give a schedule indicating the size of the 'building blocks' to reach a certain yield.

In South Africa the abovementioned approach has been advocated in recent years, but no system has as yet been developed. The main reason is that the necessity of multi-disciplinary action has not yet been accepted generally.

It is quite clear that the yields obtained and obtainable in Europe cannot be realized in South Africa because of less favourable moisture conditions. This, however, should not stop the agricultural scientists from trying to establish integrated production systems for different growing conditions. Equally the size of the 'building blocks' for realizing obtainable maximum economic yields should be established. Three examples of South African experiments in which the number of plants, the number of earbearing haulms per plant, the number of kernels per ear and their mass which all form part of building a grain yield from seed are given. When there are flaws in any of the blocks, they can be identified and an explanation for lower than economic yields can be given.

Introduction

Maximum economic yield (MEY) is not a new concept. One can trace the origin as far back as Liebig's 'Law of the minimum'. In more recent years it was depicted as a production chain with weak links.

There is, however, a cardinal difference in the way the multitude of production factors are studied and joined together as a whole. Where the previous research into problem areas was mainly carried out in isolation by one researcher or maybe one discipline, it is now undertaken by a multi-disciplinary team. (In South Africa the best 'one-man' studies on all aspects of wheat production were published by Sim (1965) and Hamman (1966). These can still be used as a starting point for multi-disciplinary action).

The reason for this development is clear. The necessity of higher productivity to be able to feed the rapidly growing world population becomes more pressing. Therefore the work of all disciplines related to crop production and animal production in the widest sense, from agrometeorologists to pathologists, must be co-ordinated and integrated into a system. The systems will be different from country to country and even from district to district within countries.

However, the study of systems developed in other countries will give direction to the research needed to arrive at integrated systems which can be used in the different areas of South Africa, taking into account the differences in weather conditions and soil potentials.

Production systems

Two systems for intensive wheat production, advocated in Europe, are the following (Bouchet, 1982).

The 'Laloux' method (promoted by Prof Laloux of the Faculty of Agricultural Science at Gembloux) places emphasis on low seeding density (200 to 220 plants per square meter) and the importance of the last leaf, which is essential in the development of yield. Plant structure is important in that robust plants will be capable of resisting adverse conditions (be it weather, disease or insects).

In contrast the 'Schleswig Holstein' method, developed by Dr Teuteberg, advocates dense plant populations (500 to 600 plants per square meter). The idea behind this system is to produce a maximum number of ears and grains per unit area. This method is labour-intensive as of necessity weak plants need a lot of care. As many as 12 to 15 operations are required to apply the necessary fertilizer and plant protection products.

TABLE1 Wheat growing systems

Treatment	Growth stage	Input in system: Low	Normal	High
Seed rate, kg/ha		120 - 160	120 - 160	160 - 250
kg N/ha	start tillering	60 - 100	60 - 100	90 - 130
	stem elongation	0	0	60
	2 - 3 node	60	60	0
	flag leaf emerg.	0	0	60
Trace elements	end tillering	–	–	+
	ear emergence	–	–	+
CCC	end tillering	–	–	1 litre
	stem elongation	–	2 litre	1 litre
Fungicides	stem elongation	–	?	+
	3 node	–	?	+
	ear emergence	–	?	+
	flowering	–	+	+
	after flowering	–	–	+
Insecticides	flowering	–	?	+
	after flowering	–	?	+
No. operations, mean 1979, 1980, 1981		2	5½	10
Total costs, kg grain/ha		720	1080	1890

In the Netherlands and Belgium it was found (Dilz, et al 1982) that the 'Laloux' method, including special attention to nitrogen application, growth regulators to avoid lodging and severe attacks of fungal diseases plus a fungicide spray at flowering (and before if required) would lead to optimization of yield (or MEY). Dilz, et al (1982) compare three growing systems to test which of these would optimize yields to the greatest extent or in other words would result in maximum economic yields.

The reference system ('recommended system') was based on the official recommendations for nitrogen supply and pest and disease control. The other two were a 'high input system' to attain maximum yields without looking at cost and a 'low input system', without growth regulator and pest and disease control. Weed control was similar for all.

The comparison between the three systems is shown in Table 1.

Although the yields of the 'high input system' were the highest, the 'recommended system' gave the maximum economic yields.

Practical application of a system

"The object of crop production is defined as the provision of food and fodder, while at the same time preserving the yielding capacity of the soil in the light of ecological, economic and social considerations so that soil cultivation is preserved over the long term" (Keller, 1982).

Optimising yields (IPI, 1982) embraces according to Keller, crop quantity and quality and should always be approached from an economic point of view. Farming should be based on an integrated production system, maintaining the soil's capacity to yield (Keller, 1982).

The yield of grain crops is determined by the number of ears per unit area, the number of grains per ear and their average mass. An example of the 'build-up' of a wheat yield from seed is given in the following schedule (Dilz, et al 1982).

The seed mass of 45 - 55 mg (1 000 ℓ mass of 45 - 55 g) is high relative to South African standards and the same holds for the grain mass.

The figure of 18 000 grains/m^2 is mentioned by Darwinkel, as quoted by Spiertz (1978), as the number above which an increase is completely compensated by a decrease in kernel mass. In field experiments Ellen and Spiertz (1975) and Spiertz and Ellen (1978) found that additional nitrogen applied at the boot stage could break this compensation mechanism.

To accomplish the different steps in this schedule and obtain maximum economic yields many interacting factors, of which some have been shown in Table 1, play a role.

	Dilz, Nederland: Ideal	South Africa Kroonstad 1983 Betta	Bethlehem 1983 Scheepers 69	Bethlehem 1983 SST102	South Africa Bethlehem 1983 Karee
Grain yield, t/ha	10	1,34	1,99	3,19	3,99
Grain mass, mg	45-55	30	30	35	35
Grains/m²	18 000-22 500	4 480	6 633	9 114	11 400
Grains/ear	35-40	16	27	40	42
Ears/m²	500-600	280	242	228	272
Ears/plant	2-3	7	11	4	2
Plants/m²	200-250	40	22	57	136
% Seed-producing plants	60-80	93	76	85	82
Seeds/m²	275-400	43	29	67	166
Seed mass, mg	45-55	35	35	30	30
Seed rate, kg/ha	120-200	15	10	20	50

FIG 1 Wheat yield build-up schedule

- Cultivars (genetics and breeding)
- Seed treatment (proper chemicals)
- Soil type and -depth
- Soil preparation (seed- and rootbed)
- Soil fertility (including mineral nitrogen — N-min)
- Planting/sowing dates
- Planting/sowing rates
- Rate of fertilizer
- Placement of fertilizer
- Time of application, Splitting, Number of splits } of N fertilizer
- Plant protection

Within the scope of this paper the abovementioned factors cannot be discussed in detail, although reference to some of them will be made.

The South African Scene

Wheat is sown in many areas of South Africa, under different climatic conditions. The main production areas and the type of wheat sown are given in Table 2.

TABLE 2 Main wheat growing areas in South Africa, planting/sowing time and type of wheat

Area	Time of planting/sowing	Type of wheat
Summer rainfall		
Northern Transvaal (Springbok Flats)	February	Summer
Orange Free State	April-July	Winter Intermediate
Winter rainfall		
Western Cape	May-June	Summer

The target field of 10 tons per ha shown in Figure 1 for European conditions is too high for dryland wheat in South Africa. The main reasons for this are the poor distribution of rainfall and the shallow soils in many of the wheat growing areas. However, yields of up to 4 and maybe 5 tons per ha could be achieved if more attention to detail is given. To this end multi-disciplinary team work with purposefully directed goals are indispensible. At this stage the average South African wheat yield is only approximately 1,4 ton per ha.

The summer wheat is sown at rates of 90 — 110 kg/ha and the winter and intermediate wheat is planted at 8 - 30 kg/ha.

In the summer rainfall areas the wheat is grown on moisture conserved during the summer months. It may occur that no rain at all falls during four months after planting/sowing. For the Springbok Flats this will mean that no rain is received during the whole growing cycle of the wheat plants as they are reaped in July. In the Orange Free State, apart from occasional falls in the winter months, the rain season will start in September. The accent in these areas lies on the methods of soil preparation in order to accummulate as much moisture as possible during the summer months.

In contrast the winter rainfall areas of the Western Cape rely for wheat and barley yields on the amount and distribution of rain during the five months from May to September. The pattern may change from flooding to drought to reasonable distribution.

The cultivars planted or sown in the different areas must be chosen on their requirements as far as temperature and day length are concerned. These requirements have been established for the cultivars which are grown on 87% of the area under wheat (Joubert 1984).

The varying conditions under which wheat is grown require flexible systems rather than 'blueprints' or similar rigid systems which are less adapted to the actual cropping conditions (Dilz, et al 1982).

In Figure 1 the 'Dilz schedule' is compared with entries obtained from experiments carried out in South Africa.

The low yield obtained at Kroonstad was mainly due to the low number of grains per ear.

The Scheepers at Bethlehem showed a low number of plants per m^2 in comparison to the number of seeds planted (only 76% of the seeds produced plants). The high number of ears per m^2 compensated for this and due to the much higher number of grains per ear (27) than at Kroonstad, the yield was reasonable.

SST102 gave a high number of grains per ear (40) and with the relatively high grain mass (35 mg) this resulted in a yield of just over 3 tons per ha.

Karee was planted at a high seeding rate (50 kg/ha). This resulted in a high number of plants per m^2. There were only two earbearing haulms per plant, but the number of ears per m^2 was higher than that for Scheepers 69 and SST102. Karee also showed the highest number of grains per ear. As a result a yield of 4 tons per ha was obtained.

The advantage of detailed analysis of the components as shown in the figures is that it will be possible to identify the weak links. After identifying these an explanation for the 'flaws' in the production chain must be sought. This may require time and effort. However, when a detailed recording system of all the steps taken and their timing as the season progresses from the reaping of the previous yield so that of the following is kept, identifying adverse conditions and/or practices should be possible. Even in the case of experiments the accurate recording is often not adhered to, but this should be optimized in the future. It is better to do fewer experiments, but treat the others like children from baby to adulthood.

The time for this sort of approach is overdue, but it remains better to tackle a problem late than not at all. Furthermore the basic ingredients for the recipe are available in South Africa. It just requires a round table gathering to put all the data on the table. There is, however, one discipline which is usually forgotten in agricultural scientists' gatherings and that is plant physiology. The contribution which can be made by physiologists is of such importance that in future they should be included. If this were done, missing links could be identified. Experimental work could be more accurately directed to find solutions for the outstanding problems. We owe this to the farming community and consequently to ourselves.

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