IMPROVED RAINFALL RETENTION WITH BASIN TILLAGE FOR SUNFLOWER.

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Summary

A basin tillage (tie-ridging or furrow diking) trial was undertaken in order to minimize appreciable run-off during the early summer pre-planting fallow period in an endeavour to improve sunflower yields. This trial was conducted on a black Arcadia clay soil at the Towoomba Research Station, 100 km north of Pretoria. The ridges spaced 1 and 2 m apart, were 15 and 25 cm high and relatively narrow (± 30 cm). Furrows were blocked at 3 m intervals. These treatments were compared with conventional shallow tine cultivation. The basins were made on 3/11/83 before noteworthy rain had fallen. The sunflower hybrid SO 222 was planted on 13/1/84 in rows 1 m apart. Very marked differences in growth, head size and seed yield occurred between conventional and basin tillage. Tine tillage only produced 785 kg/ha seed while the mean basin tillage yield was a spectacular 1502 kg/ha. Ridge spacing and height had relatively little influence on yield. Basin tillage appears to be a most effective method of improving sunflower yields on soils with a low infiltration rate in areas where moisture is limiting.

Résumé

RETENTION AMELIOREE DES EAUX DE PLUIE AVEC UNE PREPARATION DU SOL FORMANT DES CUVETTES, POUR LA CULTURE DU TOURNESOL.

Un essai de preparation du sol en formant des cuvettes (buttes et sillons formant des digues) a été entrepris en ayant pour objet de réduire le ruissemnt appréciable des eaux pendant la période de jachère du début du printemps précédant le semis, en vue de tenter d'améliorer les rendements de la culture du tournesol. Cette expérience a été menée sur un sol à argile noire Arcadia à la station de recherche de Towoomba, à 100 km de Pretoria. Les buttes espacées de 1 et 2 m avaient une hauteur de 15 et 25 cm et étaient relativement étroites (30 cm). Les sillons furent obstrués tous les 3 m. Ces traitements furent comparés à la méthode de culture conventionnelle de préparation superficielle du sol. Les cuvettes furent réalisées le 3/11/83 avant que des pluies substantielles soient tombées. L'hybride de tournesol SO 222 fut planté le 13/1/84 en lignes écartées dé 1 m. Des différences très marquées dans la croissance, dans la taille de la tête et le rendement en graines furent observées entre la méthode conventionnelle et la méthode en cuvettes. La préparation superfirielle produisit seulement 785 kg de graines à l'ha alors qu'il y eut un rendement moyen spectaculaire de 1502 kg/ha par la méthode en cuvettes. L'espacement de la butte et sa hauteur avaient relativement peu d'influence sur le rendement. La culture en cuvettes semble être la méthode la plus efficace pour emeliorer les rendements du tournesol dans les sols à faible taux d'infiltration dans les regions où l'himidité est limitée.

Introduction

In most cropping areas of South Africa inadequate rainfall is the dominant factor limiting crop yields. While little can be done to influence the quantity of rain it is possible to improve the effectiveness of rain by elimina-

ting rainfall loss as run off through improved infiltration thereby increasing available soil moisture and thus crop yields.

Heavy black clay soils (vertisols) are generally considered to be droughty as a large part of the rainfall may be lost as run off. These generally fertile self mulching soils have a high infiltration rate when dry and cracked. The infiltration rate declines to a very low level after adequate rain has wet the soil thereby causing it to expand and the cracks to close. The rain also induces surface sealing by breaking down the surface layer of an exposed soil. Once the soil surface seals over a high percentage of the rainfall can be lost as run off. This is accentuated by the occurrence of high intensity rainfall with resultant occasional severe flood and erosion damage.

Loss of rainfall as run off can be largely eliminated by employing suitable basin tillage (furrow diking or tie-ridging) practices. The basins are usually formed by placing walls of soil across furrows at 1 to 3 m intervals. Rain is retained in the basins or small dams and infiltrates into the soil over a period of time. This practice was initially developed in the early 1930's in the USA. Lyle and Dixon (1977) consider that the lack of significant yield increases with basin tillage fallowing prior to wheat and implement problems associated with basin tillage resulted in much of the interest being lost by the 1950's. They also indicated that the lack of response to early basin tillage research was subsequently attributed to fallowing having relatively little effect on wheat yield. On the other hand a review by Dagg and Macartney (1967) of basin tillage research in Central Africa from 1944 to 1962 showed spectacular results when applied to maize and beans during the growing season.

Renewed interest in basin tillage occurred in the USA in the Seventies when significant yield increases were achieved with dryland cotton and grain sorghum (Clarke and Hudspeth, 1976) on the Texas High Plains. This and subsequent research lead to the widespread use of basin tillage in low rainfall cropping areas like the Southern High Plains of Texas and Nebraska (J.A. Smit, personal communication, 1983). Basin tillage research has apparently not been done with sunflower.

This investigation was undertaken to assess the effect of basin size as influenced by ridge spacing and height on moisture conservation on a heavy clay soil during the early summer preceeding sunflower.

Materials and Methods

The trial was conducted at the Towoomba Research Station near Warm Baths 100 km north of Pretoria in a hot, low rainfall, marginal cropping area. The basin tillage treatments were achieved with ridges 1 and 2 m apart, 15 and 25 cm high and were relatively narrow (20-30 cm at base). The furrows were blocked at 3 m intervals. Ridges and cross walls were made by hand. These four treatments were compared with the conventional shallow tine cultivation in a randomized blocks design using five replicates. Gross plots consisted of 6 rows 1 m apart and 15 m long. A 3 m pathway was left between the sides of plots and a 6 m pathway between the ends of plots. Ridges were used to prevent run off from one plot running onto another. The harvested area was 2 m by 10 m.

Shallow tine cultivation was done twice prior to building the basin's on 3/11/83 before noteworthy rain had fallen. Weeds were controlled by hand hoeing. The sunflower hybrid SO 222 was thickly planted by hand in the slight furrow on 31/1/84. The basins were broken at planting and were not re-made. Fertiliser was not applied. The plant height at maturity, final stand, seed yield, hectolitre mass, 1 000 seed mass and oil concentration in the seed was recorded.

The soil was a heavy clay (Arcadia soil series) and contained 46% clay, 19% silt, 27% fine sand and 8% medium sand in the top 20 cm layer. The slope was 0,25%. This self mulching vertisol had a total water holding capacity of 344 mm/m depth and an available water capacity of 180 mm/m depth. The chemical analysis of the topsoil was: pH (H_2O) 7,5, organic matter 1,8%, P (ISPEI) 10 mg/kg, K (ISPEI) 430 mg/kg, Ca (KCℓ) 5950 mg/kg, Mg (KCℓ) 1500 mg/kg, Na (KCℓ) 0 mg/kg and Zn (ISFEI) 2 mg/kg.

The soil was dry at the commencement of the trial as very little rain had fallen since the midwinter harvesting of drought stricken wheat. The rainfall was relatively favourable during the basin tillage to planting period (368 mm) while the rainfall during the growth of the crop was very low (176 mm). The monthly rainfall from July 1983 to June 1984 was 6, 27, 2, 57, 104, 155, 155, 13, 81, 8, 0 and 27 mm respectively. This totals 635 mm which is slightly over the 45 year average of 616 mm per year.

Results

Marked run off occurred on the conventional shallow tined treatments with the result that in most cases the wetting depth was very shallow (<7 cm). Much of this moisture evaporated as the upper 5 cm of soil dried and cracked and lost some 25 mm of moisture. No run off occurred initially on the basin treatments. Ridges initially 15 cm high were effective in holding 40 and 52 mm of rain that fell on 27/12/83 and 9/1/84 respectively though some breaks in the ridges and cross walls occurred. Ridges 25 cm high did not break. Ridge height decreased with time and was less than half the original height at planting time.

Rain (62 mm) immediately after planting ensured good emergence and the required uniform stand was achieved by thinning as substantiated by the final stand counts (Table 1). Very marked differences in growth between conventional and basin tillage were clearly visible 1 month after planting and intensified until 33 mm of rain fell shortly before flowering on 8/3/84. Sunflower on the conventional tillage suffered extreme moisture stress, became severely wilted and made very poor growth. Basin tilled sunflower made fair growth and only became wilted near the flowering stage. The effect of tillage treatment on crop growth is well illustrated by the sunflower on the conventional tilled treatments becoming only 74 cm tall and having a small leaf area at harvesting while the basin tilled treatments became significantly taller (Table 1), and had a much larger leaf area though the plants were still below average in size.

Basin tillage prior to planting increased the sunflower seed yield highly significantly to 1435 kg/ha or more over the 785 kg/ha produced with conventional tine tillage. There was little difference between basin tillage treatments though the 2 m spacing between ridges gave a slightly higher yield than the 1 m spacing. The seed from the conventional tillage treatment was

exceptionally small whereas that from the basin tilled treatments was of a fair size as indicated by the 1 000 seed mass (Table 1).

The oil concentration in the seed was not significantly affected by treatment (Table 1) while the oil yield per hectare response was similar to that of seed yield (Table 1).

Discussion

Basin tillage to minimize run off and improve moisture conservation prior to planting sunflower in midsummer dramatically increased the seed yield over that achieved with conventional shallow tine tillage. The much better vegetative growth, higher seed mass and doubling of sunflower seed and oil yields is attributed to the greater quantity of moisture conserved in the soil. Although this heavy clay soil has a high water holding capacity the conserved moisture in the soil was inadequate for the attainment of high seed yields as rainfall from crop emergence to maturity was exceptionally low (114 mm). Nevertheless the production of a mean seed yield of 1502 kg/ha from the basin tillage treatments under exceptionally low rainfall is a remarkable achievement.

The shallow depth of wetting after rain on the conventionally tilled treatment indicates that much of the rain was lost as run off. Furthermore as rain seldom wet the soil deeper than 7 cm much of this moisture was lost through evaporation during the drying and cracking of this upper soil layer (5 cm). The concentration of rainfall in the bottom of the basin especially when the precipitation was low promoted deeper penetration and less evaporation loss. The possible loss of moisture from the basin treatments due to drainage or lateral movement was probably slight in this low rainfall year. However, improved growth of border rows on control plots below basin tillage plots indicates that a certain amount of lateral movement of moisture occurred.

The very marked increase in sunflower yield achieved with basin tillage corresponds with modern investigations with other crops. Effective basin tillage during the pre-plant fallow period and again after establishment doubled production of grain sorghum (Gerard *et al.*, 1983a) and increased dryland cotton yields by 32% (Gerard *et al.*, 1983b) on the Rolling Plains of Texas. Yield increases of from 10 to 25% were usually achieved in the mid Seventies (Lyle and Dixon, 1977). The greater increase in response in recent years may be due to improved basin tillage systems. Higher yield responses were, however, recorded on the upper and middle slopes than lower slopes (Gerard *et al.*, 1983a).

Visual observation indicates a reduction of basin capacity as the season progressed. This was more noticeable with the 15 cm high ridges than the 25 cm high ridges. The reduction in ridge height is probably due to both rainfall washing down the ridges and the basin rising as the swelling soil took up increasing quantities of water. Occasional overflowing of one basin into another did not markedly influence rainfall retention. Pawitz *et al.*, (1983) also observed some deterioration of the ridges, a slight reduction in basin effectiveness after overflowing and minimal soil erosion loss under basin tillage. As ridges made mechanically using large lister bottoms were somewhat wider and stronger than the handmade ridges used in the trial, it is thought that ridges 15 to 18 cm high and approximately 1 m apart should

be adequate to prevent ridges and cross walls from breaking under normal production conditions on relatively level fields. This corresponds with the Texas recommendation that relatively strong ridges 15 to 20 cm high are required to hold 50 mm and possibly 75 mm of rain (C.J. Gerard, personal communication, 1984). Available equipment is better suited to ridging approximately 1 m apart.

Although very good results were achieved with basin tillage during the moisture conservation period prior to planting sunflower it is likely that better results would have been achieved had basin tillage been done after establishment. Basin tillage during summer should combine well with conservation tillage.

Conclusions

In the medium and lower summer rainfall areas of South Africa inadequate soil moisture is usually the main factor restricting crop yields. In these areas much of the rainfall is of high intensity and appreciable loss of rainfall as run off can occur. This is especially the case on heavy clay soils once the surface has sealed over. Basin tillage that eliminated run off during the early summer moisture conservation period prior to planting sunflower doubled the seed yield over that of conventional shallow tine cultivation. Basin tillage after establishment of the crop should improve production further. Under normal production conditions ridges and cross walls should be 15 to 18 cm high with ridges approximately 1 m apart in order to produce durable basins having a rain retention capacity of over 70 mm. This new tillage system should do much to contain run off and prevent flooding and associated erosion. Basin tillage is probably the most practical and effective means of stopping run off, enhancing infiltration and improving sunflower yields in the medium and lower rainfall areas.

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TABLE 1 The effect of conventional and basin tillage during the early summer fallow period on sunflower performance

Treatments	Final stand density (1 000/ha)	Plant height at maturity (cm)	Seed yield (kg/ha)	Hectolitre mass (ha ℓ)	1 000 Seed mass (g)	Oil concentration in seed (%)	Oil yield (kg/ha)
Conventional tillage	31	74	785	40,5	47,6	48,0	387
Ridge spacing X height							
1 m X 15 cm	32	102	1471	40,0	51,4	48,7	715
1 m X 25 cm	31	103	1435	40,3	50,8	48,5	694
2 m X 15 cm	31	102	1510	39,7	53,2	48,2	725
2 m X 25 cm	32	111	1591	40,1	51,0	48,6	773
Basin tillage mean	31	104	1502	40,0	51,6	48,5	727
CV (%)	5	17	18	2	9	1	18
LSD (5%/1%)	NS	22/31	335/461	NS	NS	NS	157/216