Effect of the size and stability of soil aggregates on germination, emergence, establishment and subsequent growth of wheat.

A Thesis submitted by

SMAIL ANSER

B. Ag. Sci. University of Algiers

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Department of Agronomy

Waite Agricultural Research Institute,

The University of Adelaide

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SUMMARY

The effects of soil structure on the growth of wheat were examined in field and glasshouse studies.

Field studies

A field experiment was conducted on red-brown earth (Urrbrae loam) to investigate the influence of the size and stability of soil aggregates on germination, emergence establishment and growth of wheat. Stratified seed-beds, 8 cm deep were prepared in small plots (50 x 50 cm) from aggregates obtained by dry sieving the soil. The seed-beds comprised two layers each of 4 cm depth and the aggregate sizes were 2 - 4 mm/< 2 mm, 4 - 8 mm/2 mm and 4 - 8 mm/2 - 4 mm. Unstratified seed-beds 8 cm deep were prepared from unsorted aggregates < 8 mm diameter. Half the plots were prepared from aggregates containing 0.2 % poly (vinyl alcohol), P.V.A. to stabilise the structure. One hundred wheat grains were sown at 4 cm depth in each plot.

Germination of the wheat was satisfactory (96.9 ± 0.28) and was similar in all the plots. The number of plants which finally emerged and become established was not affected by aggregate size or P.V.A. treatments, but the rates of emergence of plants in seed-beds made of 2 - 4 mm/< 2 mm aggregates and of unsorted aggregates < 8 mm, were higher than in other seed-beds (4 - 8 mm/2 - 4 mm and 4 - 8 mm/< 2 mm). The dry weight of plants at tillering and straw and grain yields at maturity were lower for plants grown in seed-beds 4 - 8 mm/2 - 4 mm and 4 - 8 mm/< 2 mm than for plants grown in seed-beds 2 - 4 mm/< 2 mm and unsorted aggregates < 8 mm. Treatment of the soil with P.V.A. decreased dry matter production and grain yield although the decreases were not always significant at $P < 0.05$. The plots where greater dry matter and grain yield was obtained

were those which gave the earliest plant emergence and where the plants had the highest concentrations and total content of nitrogen.

Geometrical macro-structure of the surface layer of the soil was measured at sowing, germination, emergence and tillering, on sections cut through blocks of resin impregnated soil. Total macroporosity and mean pore size at 0.5 cm depth decreased during the eight weeks following sowing of the wheat particularly where the soil had not been treated with P.V.A.. The lowest macroporosity occurred at emergence, 3 weeks after sowing. Total porosity and mean pore size were consistently higher in the surface soil of seed-beds with aggregates initially 4 - 8 mm in diameter than in seed-beds 2 - 4 mm diameter aggregates. Soil treated with P.V.A. had greater porosity and greater mean pore size than untreated soil at all times of measurements.

Measurements made at 4 cm and 8 cm depth in the soil from sowing to emergence of the wheat showed that soil temperature was similar in all the plots. Soil water potential at 4 cm depth was higher (less negative) in plots made of aggregates 2 - 4 mm/2 mm than in plots made of aggregates 4 - 8 mm/2 mm and 4 - 8 mm/2 - 4 mm diameter. Meteorological factors had a greater influence on temperature and water in the soil than did the treatments. Regression analysis showed that soil temperature was most closely related to the relative humidity of the air and to rainfall which soil water potential was most highly correlated with water pressure deficit.

Surface crusting and seedling emergence

The effect of surface crusting of the soil on emergence of wheat was investigated in a glasshouse experiment. Seed-beds consisting of 8 cm depth unsorted (< 8 mm) soil overlain by 4 cm of < 2, 2 - 4 or 4 - 8 mm diameter aggregates were prepared. Wheat was sown at 4 cm depth in air dry soil and the water content of the soil was then adjusted to

20 % by weight by spraying 25 mm of 'rain' onto the soil surface. Different soil water regimes were produced by covering the soil in two sets of pots with a plastic mulch 0 and 3 days after the pots were watered, while the soil in the third set of pots was left uncovered. As expected, the strength of the soil as measured by penetrometer resistance at the time of emergence of wheat increased with decreasing water content of the soil. The strength of the crust which formed from small aggregates (< 2 mm) was significantly greater than those formed from the larger aggregates. In some instances, treatment of the soil with poly (vinyl alcohol) significantly lowered the strength of the crust. In general emergence of the wheat decreased with decreasing soil water content and with increasing crust strength. Emergence was markedly decreased or no emergence occurred as crust strength increased from 90 to 341 kPa.

Production and movement of mineral nitrogen in beds of different sized soil aggregates

Aggregates < 2, 2 - 4 and 4 - 8 mm diameter were subjected to aerobic incubation at 12 or 24 % water content for up to six weeks under two fluctuating temperature regimes *viz* alternating 12 h periods at 5 and 10°C or 12 and 24°C. Net mineralisation of nitrogen was higher at 24 % water content and 12/24°C than at lower water content and lower temperature regime. However the amounts of ammonium and nitrate produced during the six week incubation period were similar in aggregates of all sizes, and were not affected by treatment of the soil with P.V.A..

Stratified beds of aggregates (8 cm deep) underlain by undisturbed cores of subsoil (20 cm deep) were set up in leaching tubes. The beds were constructed as described for the field experiment described above and ammonium sulphate was added to the lower layer of aggregates in each tube. The columns were leached with rain water at various rates and frequencies of application and the volume and mineral nitrogen content

of the leachates were determined at weekly intervals for four weeks. Treatment of the aggregates with P.V.A. permitted greater percolation of water and greater loss of mineral nitrogen from the soil columns, particularly where the surface layer of the bed comprised coarse aggregates. The size of the aggregates had little effect on the total amount of ammonium and nitrate leached where the beds were not treated with P.V.A.

Under the conditions in which the field experiment was carried out aggregate size had more effect on plant emergence, establishment and growth of wheat than stratification of aggregates. Aggregate size and aggregate stability affected nitrogen uptake by the plants. Aggregate size and aggregate stability may have had an effect on leaching of nitrogen in the field.

DECLARATION

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university. This thesis contains no material published previously or written by any other person, except where due reference is made in the text of the thesis.

May 1982. Smail Anser

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