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The Wheat Sowing Efficiency as Affected by The Aggregate Size Distribution of Seedbed

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ABSTRACT

Under Egyptian circumstances, seeds distribution in the horizontal plane, depth of sowing, seedling emergence, crop yield and operating time for seedbed preparation are indicators of the impact of clods size distribution on the applicability of grain drill-machines for the cultivation of wheat planting. SO, this investigation was executed, where the experimental area was divided into five main plots relative to the seedbed preparation treatments. The 1st plot (P1) was prepared by a rotary tiller, while the 2nd plot (P2) was prepared via a chisel plow once followed by rotary tiller, the 3rd plot (P3) was prepared with chisel plow twice followed by the rotary tiller, the 4th plot (P4) was prepared using chisel plow once followed by wooden leveler and lately the 5th plot (P5) was set by a chisel plow twice followed by a wooden leveler (traditional treatment of wheat planting).The obtained results illustrated that increasing the mean mass diameter of clods in the seedbed led to increase in the sowing depth, plant deviation and the time required for seedling emergence time. The suitable clods size distribution soil for sowing the wheat plants with a seeds drill machine must contain various clods sizes having diameters not greater than 50mm. The suitable seedbed for using a grain drill machine was realized with a chisel plow followed by a rotary tiller at a soil moisture content between 18-22%.

***Keywords**: Chisel plough, wooden leveler, rotary tiller and grain drill machine.*

INTRODUCTION

Among cereal crops in Egypt, wheat plants have the first rank. The strategy of the Egyptian government aims to cultivate 3.6-3.7 million acres of wheat plants in the season of 2020/2021 after cultivation of 3.4 million acres in the season of2019/2020 (Agric. Res. Ins. of Economy, 2021).

The factors as decisive for seed germination and crop emergence are as follows; some of these factors characterize the seedbed at sowing time *i.e.*, depth of the seed-bed (Guerif *et al.*, 2001), soil type (Håkansson *et al.*, 2002), aggregate size distribution (Lamichhane *et al.*, 2021), stratification , moisture content (Finch-Savage, 2004), compactness of the layer directly below the seedbed and characteristics of the various layers and spatial distribution of the seed, especially the distribution depth.The other factors that identified or modify the circumstances in the seedbed during germination and emergence are precipitation (time, amount, intensity) (Forcella *et al.*, 2000), temperature (Morris *et al.*, 2010), potential evaporation and post tillage operations (harrowing, rolling, crust breaking) (Hakansson and Polgár, 1984).

A seed drill is a device used in agriculture that drilling seeds of crops by locating them in the soil to a specific depth. This ensures that seeds will be distributed evenly. The use of seed drills saves time and labour. Some equipment of metering out seeds for planting are widely use (Tripathi *et al.*, 2013). Accordingly, the seed-drilling regime is technically more feasible for sowing wheat under all various circumstances than seed broadcasting and the traditional hand method too.

Singh *et al.*, (2006) stated that the optimum sowing depth was affected by other variables and increased with the reduction of moisture content and with raising aggregate size, like with decreasing efficiency of protection against evaporation.

The increasing the planting depth decreased the ratio of germination. El-Sahrigi *et al.*, (1991) found a good correlation between sowing depth (SD) and the germination ratio (GR) with correlation coefficient: "GR = 46.443 – 8.612 Pd". El-Berry, (1991) reported that the grain yield of wheat sowing by the seed drill was about 11% higher than that of wheat sowing by broadcasting method under desert condition.

For this purpose, this investigation was executed, where its objective was to evaluate the impact of aggregate size distribution of seedbed on the efficiency of seed drill equipment for sowing wheat plants under Egyptian circumstances.

MATERIALS AND METHODS

The trial was executed at Sakha Agric. Res., Kafr El-Sheikh Governorate on a silt loamy soil during the season of 2020/2021. The experimental area was divided into five main plots according to the seedbed preparation treatments.

The 1st plot (P1) was prepared using a rotary tiller, while the 2nd plot (P2) was prepared with a chisel plough once followed by rotary tiller, the 3rd plot (P3) was prepared using chisel plough twice followed by the rotary tiller, the 4th plot (P4) was prepared using chisel plough once followed by wooden leveler and finally the 5th plot (P5) was prepared using a chisel plough twice followed by a wooden leveler (traditional treatment of wheat sowing) as shown in Fig1.

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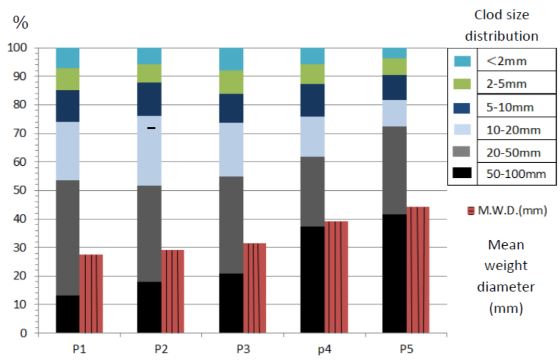

Fig. 1. Clods size distribution and mean weight diameter (M.W.D.) for the five different seedbeds

According the following equation described by Van Bavel, (1950), the mean mass diameter (MWD) of soil aggregates was calculated from the following equation;

$$\mathbf{M.W.D.} = \sum_{I=1}^{n} \boldsymbol{X1} * \boldsymbol{Wi} \text{..................(b)}$$

Where:

X_i express the mean diameter of each size fraction, mm, while W_I expresses the proportion on the total sample mass occurring in the corresponding size fraction, where the summation is carried out over all n size fraction, including the one that passes through the finest sieve.

MWD values for plots P1, P2, P3, P4 and P5 were 27.57, 29.09, 31.40, 39.10 and 44.33 mm, respectively.

The experimental area was sown by a seed drill (Make Nordsten AS; Model: CIG 200; No. of rows: 17; Spacing 12 cm and sowing width 204 cm). The sowing depth was done between 1.0-2.0 cm under seed-bed surface, depth adjustment was realized through the chain, which permits the furrow opener to work at not more than 1.50 cm of depth. All agricultural practices *e.g.*, fertilizing, irrigation and pest control were done in a manner similar to that commonly practiced at the Egyptian farms.

Calculation of seedling emergence was done from five various permanent places (0.25 m^2) for each studied plot, after sowing. Wheat seedling appeared after about 5.0 days from cultivation and irrigation, thus counts of the emerged wheat plants after seven days were made and repeated per three days until no emergence was taking place.

The aggregate size was measured depending on Braunack and Dexter, (1989) using an apparatus consisting of six different sieves mesh mounted on each other and installed on a frame. The samples of studied soil were taken from five various places after seedbed preparation and were left to dry in the air. After sieving all the individual fractions, they were massed and converted as a percentage of the total sample mass. The percentage of aggregate size greater than 20.0 (mm) in respect to aggregate size smaller than 20mm was indicated by index-C. Index-C was calculated as follows:

$$\mathbf{index - C} = \frac{\mathbf{W_g}}{\mathbf{W_a}} \text{..................(c)}$$

Where:

W_g is mass of aggregates (ϕ>20mm), while W_a is mass of aggregates (ϕ <20mm).

Two weeks after sowing and irrigation, the seed depth distribution was determined using divider and meter. The measurements were performed on all seeds in 1.0 meter length per one row. All measurements were repeated randomly three times for each plot. The number of seeds deeper than 2.0 cm in respect to the number of seeds from 0.0 to 1.0 cm of depth was indicated by index-S. Index-S was calculated as follows:

$$\boldsymbol{S} = \frac{\boldsymbol{N}}{\boldsymbol{N}} \qquad \text{........(d).}$$

Where:

N is No. of seeds deeper than 2.0 cm, while N is No. of seeds from 0.0 to 1.0 cm depth.

The crop yield of wheat plants was assessed at random from each plot taking ten samples. The square wooden frame of an area of 0.25 m^2 was used as a sampling tool. The samples were threshed by hand, weighed and used to extrapolate the crop yield (kg fed^{-1}).

The plant populations and distribution in the row were measured by taking five samples from randomly selected one-meter lengths for each plot. The distance between successive plants on each row was measured by the meter. Plant deviation from the row was counted and used to calculate the percentage of plant distribution to the total plant in the field. The uniformity of plant distribution in the row can be estimated from the value of index-K; using the following equation by Kan (1980): Ismail equation

$$\boldsymbol{K} = \frac{\boldsymbol{S}}{\boldsymbol{X}} \qquad \text{........(e).}$$

Where:

S is theoretical mean distance between plants in row (cm),while X is the average of actual mean distance between plants in row. (cm).

When K=1, the wheat plants distribution 'in a row is perfect uniformity.

When K<1, some wheat plants were disappeared from the row.

When K>1, many wheat plants grow together in short distance and formed many dispersion groups along-side the row.

RESULTS AND DISCUSSION

1. Sowing depth

Fig 2 shows the typical sowing depth after drilling for all plots.

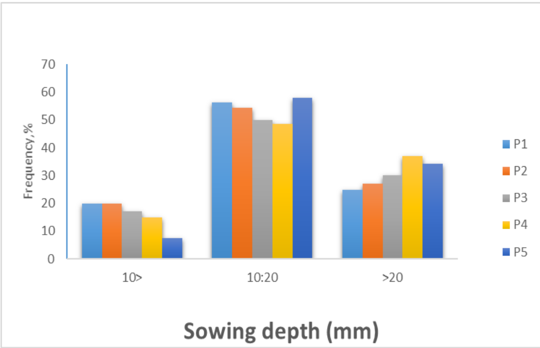

Fig 2. Impact of aggregate size distribution in five various seedbed on the seeds distribution at the various sowing depths.

Regarding to plots, it is clear that more than 50 % of the wheat seeds were planted in soil depth between1.0-2.0 cm depending on the pre-adjusted working depth. While the remaining 50 % of the wheat seeds were distributed either below and/or above the 1.0 -2.0 cm layer. The obtained results illustrate that the better wheat seeds distribution after drilling was realized at plots P1 and P2 (index-S values were 1.20 and 1.30, respectively), whilst bad distribution was obtained at plots P3 and P4 (index-S values were 2.40 and 3.60, respectively). From the findings, it can be noticed that the index-S values were affected as a result of the aggregate size distribution particularly the values of index-C. The influence of index-C values on the index-S values is expressed as in the statistically derived relationship in the form of:

$$S` = a + b \ln C` \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\text{ (f)}$$

Where:

S` is index-S value, while C` is index-C value. wherase, a & b are constants.

Data also indicate a good relation with r (a high correlation coefficient) between index-S and index-C values which can be represented via the equation of $S` = 1.1606 + 2.4813 \ln C`$ r. = 0.9928 ……… (g)

Fig 3 is a graphical representation of these results, where It may be noticed that the index-S values increased as the values of index-C increased. This trend may be due to the fact that the seed drill machine may be unsuitable for sowing at seedbeds with a high percentage of large aggregates possessing a diameter greater than 20.0 mm.

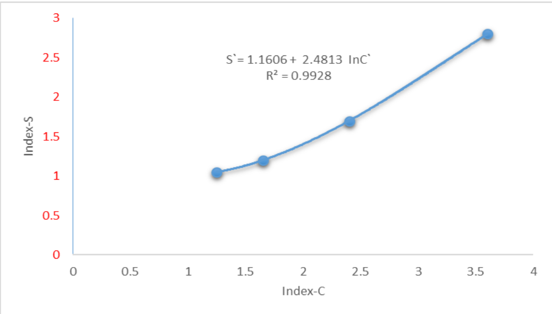

Fig 3. The relation among the percentage of aggregate size greater than 20.0 (mm) in respect to aggregate size smaller than 20.0 mm (index-c) and the No. of seeds in soil deeper than 2.0 cm in respect to the No. of seeds from 0.0-1.0 cm depth (index...S).

2. Seedling emergence

Fig 4 shows the seedling emergence % (E`) versus the No. of days after sowing and irrigation (N`) and clods size distribution. However, the following statistical relationship has been derived from the experimental data between the No. of days (N`) and seedling emergence % (E`) at various clods size distributions.

$$E` = a + b \ln N` \quad \ldots\ldots\ldots\ldots\ldots\text{ (h)}$$

Where:

E` is seedling emergence (%), while N` is No. of days after planting and irrigation. a & b are constants.

These relations are for different plots as follows:

- Regarding plot P1: $E`=-20.2067 + 47.0569 \ln N`$ r. = 0.9987 (i)
- Regarding plot P2: $E`=-12.0389 + 42.1609 \ln N`$ r. = 0.9244.(j)
- Regarding plot P3: $E`= 32.6225+ 24.3594 \ln N$ r. = 0.9838 (k)
- Regarding plot P4: $E`= 44.7885 + 20.2217 \ln N`$ r. = 0.9915. (l)
- Regarding plot P5: $E`= 50.1663 + 19.8873 \ln N`$ r. = 0.9611 (m)

Considering the statistically derive equations above, it may be evident that the constant (b) can be considered a good indicator for rapid seedling emergence. This means that plants wilt reach the maturity stage at the same time and can be harvested under a good condition with minimum yield losses.

Fig 4 indicates that the lower emergence (%) value was realized on the 7th day at plots P1 and P2 than at any other plot. After this date, the average seedling emergence (%) value at plots P1 and P2 was rapid as compared to other plots. This may be attributed to the high percentage at large size aggregates presented in plots of P3, P4 and P2, which in turn leaves large pore spaces for seeds to drop in. The tendency of soil settlement then becomes obvious. Wheat seeds are covered in this case with various thicknesses of soil layers after the irrigation process. However, in most cases, a lot of seeds in plots of P3, P4 and P2 are covered with layers less in thickness compared to those established in plots of P1 and P2. Thus, the seedling percentage was high at the early emergence stages. Thicker layer in plots of P3, P4 and P2 led to some delaying for the seedling emergence compared to that realized with the plots of P1 and P2. It can be noticed that seedbeds with aggregate size distribution gotten in plot P1 possessing a mean weight diameter of about 27.56 (mm) and plot P2 possessing a mean weight diameter of about 29.08 (mm) were more suitable for sowing wheat plants using the drill machine.

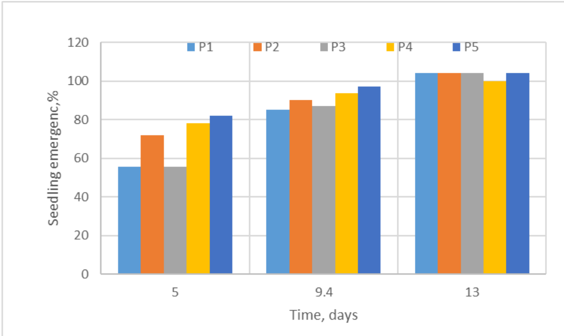

Fig. 4. The relation among the seedling emergence (%) and time (days) after planting and irrigation process for each plot.

3. Plant distribution

As shown in Fig 5, Plant distribution form in rows was generally the same in all plots, but most of the wheat plants in plots of P5 and P4 were at a distance between 0.0-2.0 cm compared to the other studied plots. The actual mean distance among wheat plants in a row at plots P1, P2, P3, P4 and P5 are 3.02, 2.97, 3.03, 2.50 and 2.50, cm, respectively, whereas the theoretical mean distance for all investigated plots was above 2.95 cm.

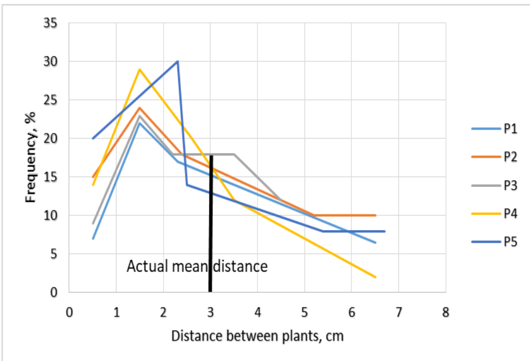

Fig 5. Impact of aggregate size distribution in the seedbed on the wheat plant distribution and actual mean distances among plants in the row distance.

Depending on Kan equations, Fig 6 illustrates the best uniformity of wheat plant distribution was realized under plots of P2, P1 and P3, wherever the K-values were 0.9936, 0.9768 and 0.9736, respectively on the other hand, the results illustrate that the wheat seed distribution in the horizontal plane was influenced by the clods size distribution.

Also, the Fig 6 show a good correlation among P_d (plant dispersion percentage) and M.W.D (mean weight diameter of aggregates). The data realized a logarithmic correlation with a correlation coefficient of 0.9943, where this correlation can be represented through the following equation:

$$P_d = -130.5269 + 44.462 \ln (M.W.D.) \quad \ldots\ldots\ (n)$$

Where:

Pd (%) expressed plants deviation fronts the row, while M.W.D (mm) expressed mean weight diameter of soil aggregate.

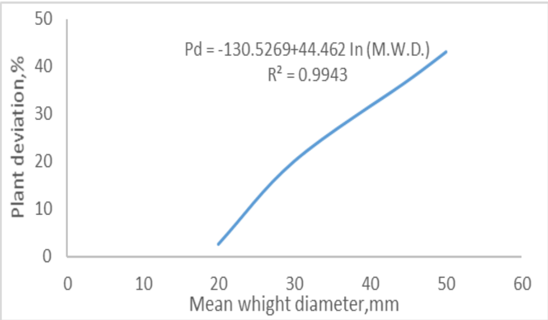

Fig 6. Impact of the mean weight diameter of aggregate on the plant deviation from the row.

From this equation, the wheat plant deviation from the row increased as MWD of aggregate increased and vice versa, but the deviation of wheat plants will be zero if the MWD of the aggregates is not larger than 18.0 mm.

4.Crop yield and economics

Fig 7 illustrates the crop yield (kg fed^{-1}) and the time required for seedbed preparation (h fed^{-1}) for each studied plot. The findings show that the highest values of total wheat yield were realized in plots of P3 followed by P2 then P5 then P1 and lately P4. The yield in plot P3 exceeded those in plots P2 and P5, but the increase was non-significant.

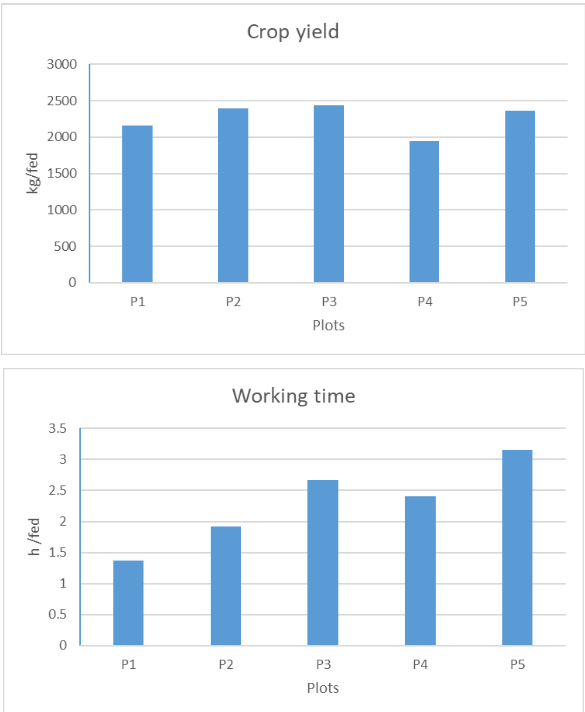

Fig. 7. Crop yield and working time needed for seedbed preparation at various plots.

Depending on the marketable price, the cost required for seedbed preparation for each operation before seed sowing is shown in Table 1, where the costs were average contractor's charges for 2020.

Table 1. Operations and contractor's charges/fed for contracting seedbed preparation regime for planting wheat.

Field operation	Costs, EL fed^{-1} P1	P2	P3	P4	P5
Chisel plow first run	-	200	200	200	200
Chisel plow second run	-	-	105	-	105
Rotary tiller	274	180	180	-	-
Wooden leveler	-	-	-	98	98
Total	274	380	485	298	403

The wheat yield saving of the P3 plot compared to the plot of P2 wasn't matched by the cost of seedbed preparation. On the other hand, the saving in wheat yield of about 41.0 kg fed^{-1}, which is worth approximately LE 196.8 per fed at prices of 2021 was relatively small in relation to raising the total cost of seedbed preparation.

According to the above results, it may be concluded that the plot of P2 recorded the same saving in addition to the large time saving as compared to the plot of P3. Thus, the economical wheat yield can be realized via the seed drill machine at seedbed circumstance similar to that of P2 plot possessing a mean weight diameter of about 29.08 (mm). Also, it can be noticed that the time consumed for seedbed preparation under plot P2 was less by 64.0% as well as the seedbed preparation cost less in addition to the wheat yield increased as compared to the conventional seedbed preparation.

CONCLUSION

From the current study, it can be arrive at the following conclusions:

1. Decreasing the percentage of the aggregate (ϕ >50.0, mm) in the seedbed caused to increase in the mean distance between adjacent seeds in a row for a given No. of seeds/unit area and then the yield of wheat was increased.
2. Increasing the plant deviation percentage with large aggregates (ϕ >50.0, mm).
3. Reducing the aggregate size percentage greater than 20.0 mm in respect to an aggregate size smaller than 20.0 mm (index-C) decreased the time required for all seedling emergence and the uniformity of wheat plant distribution was ameliorated.

Generally, from the above findings, it can be concluded that the suitable seedbed for using the drill machine must contain various aggregate sizes having diameters not greater than 50mm. The percentage of greater aggregates (ϕ 20.0 – 50.0, mm) and likewise the small aggregates (ϕ <2.0, mm) must be kept to a minimum value of total aggregates.

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كفاءة زراعة القمح المتأثرة بحجم وتوزيع حبيبات التربة المركبة بمرقد البذرة.

محمد مصطفي أبو حباجة

قسم الهندسة الزراعية -كلية الزراعة – جامعة المنصورة.

في ظل الظروف المصرية، يُستخدم توزيع البذور في المستوى الأفقي، وعمق الزراعة، وانبات الشتلات، وإنتاجية المحصول، ووقت اللازم لإعداد مرقد البذرة كمؤشرات لتأثير تأثير حجم وتوزيع حبيبات التربة المركبة على امكانية استخدام آلة التسطير لزراعة القمح. لذلك، تم إجراء هذا البحث، حيث تم تقسيم المساحة التجريبية إلى خمس قطع رئيسية وفقًا لمعاملات تحضير مرقد البذور. تم تحضير القطعة الأولى (P1) باستخدام المحراث الدوار، بينما تم تحضير القطعة الثانية (P2) باستخدام المحراث الحفار مرة واحدة متبوعًا بالمحراث الدوار، وتم تحضير القطعة الثالثة (P3) باستخدام المحراث الحفار مرتين متبوعًا بالمحراث الدوار، تم تحضير القطعة الرابعة (P4) باستخدام المحراث الحفار مرة واحدة متبوعًا بالزحافة الخشبية وأخيراً تم تحضير القطعة الخامسة (P5) باستخدام المحراث الحفار مرتين متبوعًا بالزحافة الخشبية (المعاملة التقليدية المستخدمة في زراعة القمح). أوضحت النتائج المتحصل عليها أن زيادة متوسط قطر الحبيبات الموزون في مرقد البذرة أدى إلى زيادة في عمق الزراعة وانحراف النبات عن الصف والوقت اللازم لظهور الشتلات. توزيع حجم حبيبات التربة المناسب لزرعة نباتات القمح بآلة تسطير الحبوب يجب أن تحتوي على أحجام مختلفة لحبيبات التربة المركبة بأقطار لا تزيد عن ٥٠ مم. تم تحقيق مرقد البذور المناسب لاستخدام آلة تسطير الحبوب باستخدام محراث الحفار متبوعًا بآلة المحراث الدوار بمحتوى رطوبة تربة يتراوح بين ١٨-٢٢٪.