Evaluation of a pneumatic precision planter Performance for direct seeding of onion (*Allium cepa* L) on raised beds under Gezira conditions, Sudan

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ABSTRACT

This experiment was conducted at the Experimental Farm of the Facultyof Agricultural Science, University of Gezira (latitude $14^0\,25'39.43''$ N, longitude $33^0\,29'\,21.39''$ E) to investigate the possibility of direct seeding of onion on raised beds of the Gezira clay soil. Four main direct seeding methods of onion were tested, using a pneumatic precision planter and compared with the traditional transplanting method. The treatments were seeding at 4km/hr (S_4) with covering device, seeding at 4km/hr without covering device, seeding at 7km/hr (S_7) with covering device, planting at 7km/hr without covering device and control (transplanting). A randomized complete block design (RCBD) was used with four replications. Results showed that onion seeds could be directly sown by the pneumatic precision planter on raised beds using 7km/hr speed. Although all the methods gave

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plant population far below the recommended, no significant differences were found among treatments. With regard to bulb diameter, yield and number of bulbs, the direct seeding methods gave the best results compared with the conventional method. Plant population was not significantly different between the conventional method and S_7 treatment.

INTRODUCTION

Onion is the most important and popular vegetable crop in the Sudan. It is grown in most States of the Sudan as a winter crop during the period from October to February (Ali,2009)

Soil structure is important for onion establishment. An ideal soil structure is a mixture of small granules mixed with enough fine-textured soil particles to provide a firm, smooth planting surface. Extremely fine soil particles work well if the beds do not become crusted by rainfall or flooding of the beds before germination (Cogran*et al*, 2000). However, the crusts that form on a powdery soil tend to be tougher than crusts that form on soils with more granular structure. Larger size granules (clods) may interfere with precision seed placement, and if the large granules are not mixed with fine textured particles, seeds may settle to greater than desirable depths. At optimum conditions, seeds planted in cloddy soils tend to have uneven and erratic germination.

A desirable planting surface requires pre-irrigation on most soils. The sequence of operations in soil preparation starts with plowing, followed by disk harrowing leveling, ridging, pre-irrigation, rotary cultivation, shaping, and applying pre-plant fertilizer (Corgan*et al*, 2000). The pre-plant fertilizer is most effective if applied after pre-irrigation. If the fertilizer is to be banded, then it can be done by mounting the fertilizer applicator with the bed shaper. Fertilizer broadcasting is applied following rotary cultivation and incorporated by running the rotary cultivators for a second time.

For salad onions, a bed system with several rows at a narrow spacing is used. For bulb production, beds can also be used or machinery can be adapted to other systems, like ridges, furrows, or on the flat, using precision seeders. Bracy and Parish (1998) stated that different planters gave different overall uniformity and percentage of misses that ranged from 15% in the Stanhay belt-type seeder in comparison to 5% for the Carraro vacuum-type model.

Ideally, under direct seeding, the soil should be kept damp until the seedlings emerge. Drying out at the establishment stage can lead to uneven emergence, which reduces uniformity of development throughout the life cycle of the crop. A well worked but dense layer of soil is needed below the seeds so that water can reach the seeds by capillarity. A press wheel or a roller is used to firm the soil around the seed, as close contact of the seed with the soil improves water uptake, a factor that enhances more even germination and allows good primary root development. Under seedbeds with a risk of crust formation, flat profiles must be avoided. Under such conditions, concave bed profiles above the seed are preferred. If stagnant water is a problem, a convex profile is recommended (Kretschmer, 1994).

Whalley*et al*. (1999) showed that mechanical compaction from 0.19 to 0.75 MPa of mean penetrometer pressure reduced the rate and extent of onion shoot development, but affected roots less than shoots.

The development of agricultural machinery and chemical weed control provided opportunities for direct seeding of onion in the Sudan, considering the high wages of manual labor for transplanting. Several experiments were conducted in this regard in the last three years in Sulait Project east of Khartoum State and some special projects in the River Nile State. Tests proved to be successful in reducing production cost by about 30% compared to the traditional method (manual transplanting). In addition, it doubled the yield and resulted in early harvest (Ali, 2009)

McRobie (1990) reported that precision planters resulted in the correct seeding depth, high germination percentages and reduced amount of seeds required. They also allowed easier weeding and drilling of fertilizers.

Traditional method:

Seeds are sown in the nursery using a seed rate of about 4.8 kg per ha. The nursery usually established during the period from mid-August to September and the seedlings transplanted to the field after about six weeks from sowing in the nursery. Irrigation of seedlings should be stopped a week before uprooting of the transplants. A light irrigation recommended for help in uprooting of seedlings without injuring the roots. The soil is plowed and super-phosphate is added at the rate of 96 kg/ha, and the soil is refined and leveled when sowing in light loam soil and ridged into 70 cm furrows in case of heavy clay soil. There are usually four lines of transplants on the ridge. When transplanting in flat, the lines should be 20 cm apart and the distance between plants is 5-10 cm. The field must be irrigated immediately after transplanting. Transplanting is preferably practiced early in the morning or late in the afternoon. A month after transplanting, urea fertilizer at rate of 100 kg /ha will be added and the same dose repeated one month after the first dose (Ali, 2009).

The objective of this work was to investigate the performance of a pneumatic precision planter for direct seeding of onion seeds.

MATERIALS AND METHODS

The experimental site:

The experiment was conducted at the Experimental Farm of the Faculty of Agricultural Sciences, University of Gezira, Wad Madani, Sudan, the winter season of the year 2015. The Farm is located at latitude $14^0\,25'39.43''$ N, longitude $33^0\,29'\,21.39''$ E.The soil is heavy cracking clay; characterized by high water-holding capacity and poor internal drainage (Metrological Station, 2012).

layout:

Four main direct seeding methods of onion were tested and compared with the traditional transplanting method. The treatments were as follows:

1. Direct seeding on raised beds using a pneumatic precision planter at the speeds of:
    a. Seeding at 4km/hr (S_4) with covering device (S_4WCD)
    b. Seeding at 4km/hr without covering device (S_4WOCD)

c. Seeding at 7km/hr (S_7) with covering device (S_7WCD)
d. Seeding at 7km/hr without covering device (S_7WOCD)

2. Control (manual transplanting).

Raised bed shaping:

The bed dimensions were 150 cm wide (from furrow centers) the top furrow width was 55cm and about 20cm deep. The randomized complete block design (RCBD) was used with four replications. The plots were rectangular in shape (42m×3.2m). The following parameters for the planter and the crop were tested:

1. Planter parameters:
   a. Field capacity.
   b. Field efficiency.
   c. Fuel consumption.
2. The crop parameters:
   a. Plant population.
   b. Onion bulb yield.
   c. Bulb diameter.

Materials:

Mahindra tractor (80HP) was used to power the implements,chisel plow for primary tillage, ridger, ditcher to open water ditches, bed shaper to establish the beds and a pneumatic precision planter. Onion seeds (Baftaim cultivar) was used. Other materials included Petri dishes, stop watch, measuring tape, granulated and soluble fertilizers, Imidacloprid 17.8 % SLPymetrozine (Chess 50WG) pesticides, Knapsack sprayer,*Najjama* for weed control, a square meter frame, plastic bags, digital balance, a vernier to measure the diameter of the bulb and a 100 m measuring tape.

Pneumatic planter:

Description	Value
Model	ORIETTA CS
Working width	1.5-2.0 m
Number of planting units	6
No. of rows per unit	2
Maximum required tractor pump pressure	180 bar
Recommended working speed range	3-5 (km/h)

Pattern of sowing:

The pneumatic precision planter was used for direct planting of onion seeds. The planter air vacuum was set to 20 mille-bars, the twin rows are seven cm spaced. Between units spacing was set to 11cm, while the spacing between seeds within row was adjusted to 10 cm. The seed plates used have 48 cells arranged into two rows; the cell is 1.1mm in diameter. Sowing depth was adjusted to 2 cm.

Experimental Methods:

Tractor forward speed:

For measuring the actual speed of the tractor in the field, a distance of 50 m was measured and fixed by two flags using a 100 m measuring tape. The planter was hitched to the tractor and put into operation depth and gauge pressure. Two speeds were tested. The second gear was used for the first speed (S_4) (4 km/hr), while the fourth gear was used for speed (S_7) (7km/hr). Time taken to cover this distance and the corresponding engine rpm for each speed were recorded. Each speed was replicated four times. The means were taken and then the actual average speed was calculated by the following formula;

$$\text{Actual operation speed}\left(\frac{\text{km}}{\text{hr}}\right)=\frac{\text{covered distance(m)}}{\text{elapsed time (min)}}\times\frac{60\ \text{min}\times 1\text{km}}{1000\ \text{m}\times 1\text{hr}} \quad \text{.....(1)}$$

Fuel consumption:

The tractor fuel tank was topped at the starting point of planting 4.2 ha area. After the completion of planting the area, the tractor engine which was stopped and the fuel tank was refilled using a measuring cylinder. Then the fuel consumption was calculated by the formula;

$$\text{Fuel consumption}\left(\frac{\text{L}}{\text{ha}}\right) = \frac{\text{Consumed fuel (L)}}{4.2\ \text{(ha)}}. \qquad \text{.........(2)}$$

Operating time:

A distance of 50 meters was marked by two flags fixed outside the boundaries of the experimental plots in order to determine the speeds of planting. The time required to cover the distance was recorded using the stopwatch.

Machine field efficiency:

The theoretical field capacity was calculated using the formula:

$$C_T = \frac{sw}{c}$$

Where:

C_T is the theoretical field capacity (ha/hr), s is the forward speed (km/hr), w is the implement width (m) and c is a constant (10). The actual field capacity was obtained by recording the time required to cover 0.1 ha (hr/ha), then dividing one by that number gives the actual field capacity in (ha/hr). Machine field efficiency was calculated by the following formula;

$$\text{Machine field efficiency(Ef)\%} = \frac{\text{Actual field capacity}\left(\frac{\text{ha}}{\text{hr}}\right)}{\text{Theoratical field capacity}\left(\frac{\text{ha}}{\text{hr}}\right)} \times 100\% \qquad \text{.........(3)}$$

The two tested speeds of 4 and 7km/hr were estimated from the tractor gear-speed range and accordingly the theoretical calculated field capacities of 0.6 ha/hr for speed 4km/hr and 1.05 ha/hr for speed 7km/hr were calculated based on 1.5m effective width of the planter as shown in Table 1.

Plant population:

A square meter metal frame was used for the determination of plant population.

Onion yield:

Yield of onion was obtained using a square meter frame of metal rod. It was laid on the mature onion randomly, and the onion from the determined area (meter square) was collected for each plot. Plastic bags were used to take samples of the onion. The collected material was weighed using a digital balance.

Seed germination test:

A laboratory germination test for seeds carried out two weeks before executing the experiment. Five replications in five Petri dishes, the base of each Petri dish was covered with wet filter paper. A sample of 100 random seeds was placed in each dish. Germination count was recorded daily until a fixed number of germinated seeds per dish were obtained.

Statistical analysis:

Data were subjected to standard analysis of variance procedures. The Duncan’s Multiple Range Test was used for means separation. The SPSS was used for analysis of the data.

RESULTS AND DISCUSSION

Thousand seed weight and germination test:

The 1000 seed weight was found to be 4.02g and the germination test was 80.2%. The recommended seed rate was divided by the germination percentage. Accordingly, the seed rate was more than the recommended by 20%.

Machine field efficiency:

Table 1 shows that the actual field capacities were 0.6 and 1.07 ha/hr for S_4 and S_7 respectively, with time efficiency of 0.97 and

0.98 for S_4 and S_7 respectively when compared to the theoretical. The result indicated uniform and steady speed at S_4, but some acceleration and deceleration at speed S_7. This may be attributed to the fact that there was no need to slow down at the cross ridges or depressions for (S_4) while (S_7) necessitates slowing down and speeding up. The covering devices were not expected to affect plant population, rather than straightness of planting rows. Comparing the actual field capacity of the two speeds (S_4) and ($S_{7)}$, (S_7) resulted in 47% increase in actual field capacity while the calculated was 43% only.

Table 1 Estimated and actual field output

Item	**Estimated**	**Actual**
Estimated capacity (ha/hr) @ 4km/hr	0.60	0.58
Estimated capacity (ha/hr) @ 7km/hr	1.05	1.07
Actual Field efficiency (%) @ 4km/hr	97	97
Actual Field efficiency (%) @ 7km/hr	98	98
Fuel consumption (L/ha) @ 7km/hr	-	8.5
Seed consumption (kg/ha)	-	1.79

Effect of treatments on plant population:

The effect of treatments on plant population was significant ($P \leq 0.05$). Fig 1 shows the results of plant population for the five treatments. The control (C), S_7WCD and S_7WOCD resulted in a significantly higher plant population of 24 plants/ m^2 for each. While treatments S_4WCD andS_4WOCD resulted in a significantly lower plant population of 16 plant/ m^2 and 14 plants/ m^2, respectively. The low plant population under direct seeding of (S_4) might be due to the destruction of some seedlings during hand weeding which was estimated to be about 15% of the established seedlings. However, plant population for all treatments was far below the recommended 67 plants/ m^2 for direct seeding and 40 plants/ m^2 for transplanting. The overall average field results showed a deviation from the recommended of aboutb35%, 36% and 60%, for S_4, S_7 and C respectively. Fig.1 shows that the covering devices had no effect on plant population for all treatments.

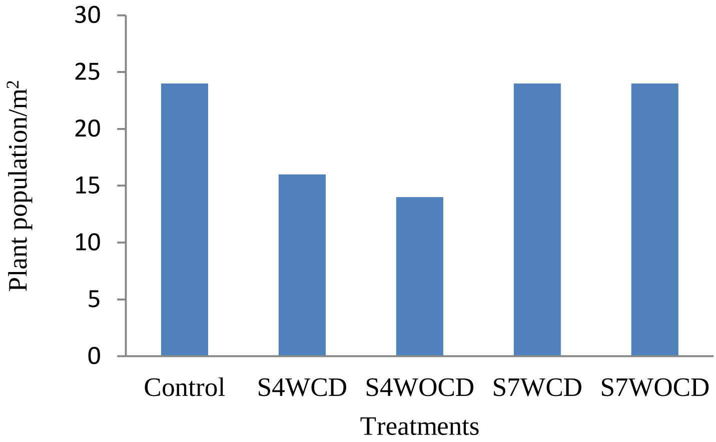

Fig 1. Effect of treatments on plant population

Number of bulbs per square meter:

Figure 2 shows the effect of treatments on the number of bulbs per square meter. The difference was found to be significant for treatments S_7WOCD, S_7WCD and C resulted in 20, 17 and 17 bulbs per m^2, respectively, without a significant difference between them. Treatments S_4WOCD and S_4WCD resulted in 14 and 13 bulbs/m^2, respectively. This difference was considerable when estimated in sacks of onion per ha. The difference was found to be 107.7 sacks per hectare (3.5 ton/ha on average basis of 650 bulbs per sack).

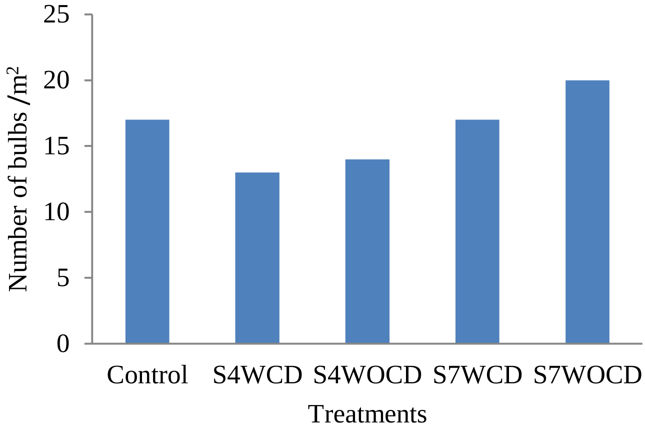

Fig 2 Effect of treatments on number of bulbs

Bulb yield:

Figure3. Shows that the effects of treatments on bulb yield were not significant. Treatments S_4WCD gave the highest yield (1.12 kg/m^2) followed by treatment C (1.09 kg/m^2). Treatments S_7WOCD and S_7WCD resulted in the least yield (0.86 and 0.77 kg/m^2, respectively).

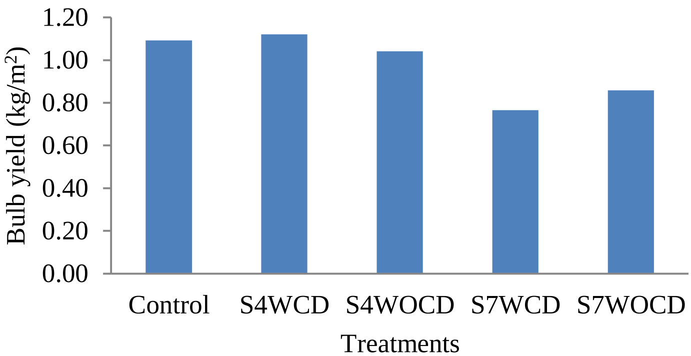

Fig 3 Effect of treatments on bulb yield

Bulb diameter (cm):

Fig 4 shows the effects of treatments on bulb diameter. There were no significant differences among treatments in bulb diameter. Bulbs from different treatments had round shape. Treatments S_7WCD and S_4WOCD resulted in 5.3 cm and 4.6 cm as largest and smallest bulb diameter, respectively.

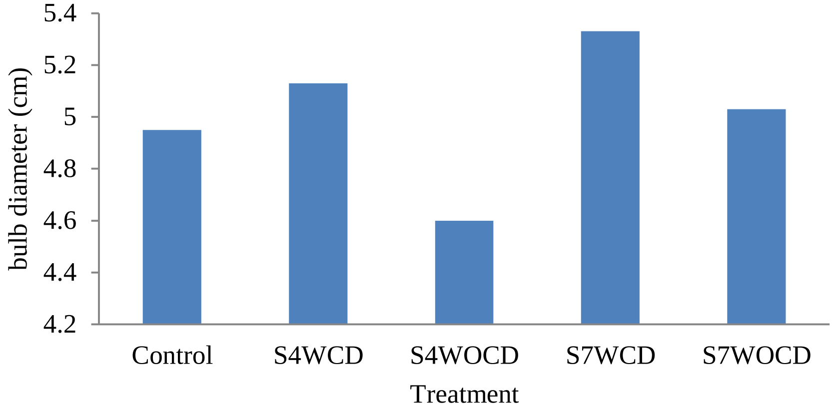

Fig 4 Effect of treatments on bulb diameter

It was found that bulbs near the furrow are larger in size than those in the inner position of the bed. Although this difference is not significant, this may be attributed to the availability of water due to lateral and capillary movement. Plants on the lower side might have received more water and less ventilation while on the higher side received adequate water and good ventilation.

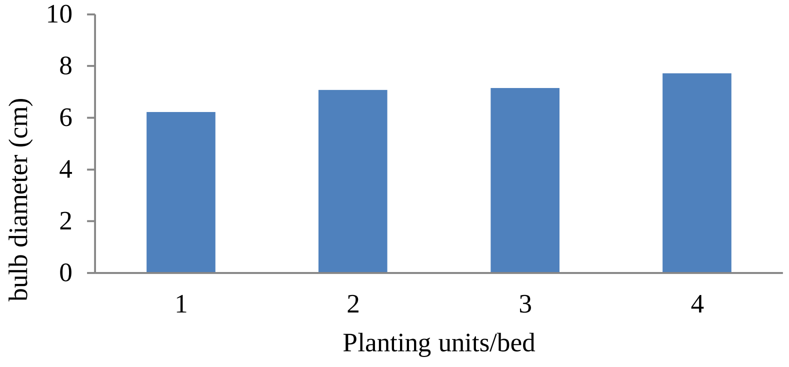

Fig 5 bulb diameter

Conclusions and Recommendations:

1. Direct seeding of onion on raised beds under Gezira conditions was successful.
2. Planting speed of 7 km/hr should be maintained to maximize tractor output, time efficiency and minimize fuel consumption.
3. Adoption of direct seeding is recommended when high value and expensive seeds are used because it cuts down the required seeds by about one third.
4. Use of S_7WOCD planting speed should be maintained to maximize tractor output, time efficiency and minimize fuel consumption.

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تقييم أداء الزراعة الدقيقة في الزراعة المباشرة لبذور البصل على مساطب في ظروف الجزيرة، السودان

الخلاصة

Evaluation of a pneumatic precision planter Performance for direct seeding of onion (*Allium cepa* L) on raised beds under Gezira conditions, Sudan

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تم اجراء هذه التجربة بالمـــزرعــــة التجـــريبية بـــكلية العـــلوم الـــزراعية جـــامعـــةالجـــزيرة (latitude 14^0 25′39.43" N, longitude 33^0 29′ 21.39" E) لتحديد امكانية زراعة بذور البصل مباشرة في تربة الجزيرة الطينية. تم اختبار اربعة طرق زراعة مباشرة والطريقة التقليدية لزراعة البصل. كانت المعاملات هي الزراعة بسرعة ٤ كم/الساعة بدون جهاز تغطية للبذور ومع جهاز تغطية للبذور، زراعة بسرعة ٧كم/الساعة بجهاز تغطية للبذور وبدون جهاز تغطية للبذور بالإضافة للطريقة التقليدية. تم استخدام التصميم العشوائي الكامل باربعة تكرارات. اتضح من التجربة امكانية الزراعة المباشرة لبذور البصل بسرعة ٧ كم /الساعة. بالرغم من ان كل الطرق المستخدمة اعطت عدد نباتات قليل مقارنة بالموصى به، إلا انه لا توجد فروقات معنوية بين المعاملات المختلفة. بالنسبة لقطر البصلة و الإنتاجيةوعدد البصلات فإن الزراعة المباشرة اعطت نتائج افضل من الطريقة التقليدية. عدد النباتات في المتر المربع كان متساويا بين الطريقة التقليدية والزراعة بسرعة ٧ كم/ الساعة.

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