Comparison of Different Planting Machines with Manual Sowing for Sorghum Crop in Central of Sudan

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ABSTRACT

The experiment was conducted in the University of Gezira Experimental farm during 2004-2005, and in Taiba Block (Gezira Scheme), during 2005-2006, to evaluate the performance of two different planting machines (pneumatic and belt planters), in comparison with manual sowing of sorghum. The performance evaluation covered the plant traits (plants emergence, spacing, population and crop yield) and machine parameters (seed rate, field capacity, field efficiency and cost). Field results showed that no significant differences were evident between the two planters with regard to seed rate, but manual sowing resulted in significantly (p=0.05) higher seed rate compared to planters sowing. Results indicated that no significant differences were detected between the planter types for plant population and spacing between plants, but there were highly significant (p=0.01) differences between the machine and manual sowing, which resulted in highly significantly plant population and spacing between plants. The use of planter saved about10 Kg/ha of seeds, which is about 66.7% lower than that used with manual sowing method. The cost of machine sowing was found to be 27% lower than that of manual sowing. Moreover, machine sowing, eliminated the need for thinning operation, which was found to be essential in the case of manual sowing. Effective field capacity, efficiency and fuel consumptions were not affected by the type of machines used over different ranges of planter speeds but with the increased planter speeds, effective field capacity was significantly increased, while field efficiency and fuel consumption per area were decreased. The required average time for planter sowing was found to be 0.6 machine-h/ha, while manual sowing required an average time of 12.5 man-h/ha, which is about 21times the average time requirement for planter sowing. Compared to the manual sowing, machine sowing was found to be a proper method for sorghum sowing in the Gezira Scheme.

INTRODUCTION

Polices should focus on improving agricultural productivity via introduction of new verities and application of technical packages, and the farmer must be provided with knowledge, facilities and resources to enable him to produce more and better crops quality.

Food production can be improved by an increase in the cultivated area (limited possibilities) and by higher yield per area, so that mechanization is essential for achieving this agricultural production and food security goals.

A scarcity of labor for agricultural operations especially during relatively short planting and harvesting periods, which will increase further during the coming years as the results of continuous movement from rural area to the urban centers, so it is expected that the agricultural mechanization will solve these problems. Pothecary (1968) stated that the increasing importance of (timing) which is vital for field operations, necessitates the gradual replacement of hand labor

by machinery, not only for such arduous tasks as land preparation, but also where labor bottle necks occur in tasks, such as planting and weeding.

Effective and efficient use of farm machinery leads to increase in the precision of farming operations such as optimum spacing between plants, plant population, seed depth and application of fertilizer ….etc.

Jacobs and Harrel (1983) identified the word planter as that machine which can be adjusted to place the seeds of great varieties of crops in the soil with high degree of accuracy for rate, depth and spacing.

El-Awad (2003) evaluated the mechanical sowing of various field crops of cotton, sorghum and sunflower in comparison with manual sowing, he stated that the seed rate of cotton, sorghum and sunflower were reduced by about 4%, 33% and 17% respectively and seeding by machines is more cheaper than the hand work (reduction of operation cost).

Singh *et al.* (2005) reported that precision planting is defined as the placement of single seeds in the soil at the desired plants spacing.

Zaidi *et al.*(1998) from their experiment on the Gaspardo SP250 (pneumatic planter), reported that the planter used 3.7 kg/hectare of sunflower seeds (optimum seed rate required), while the ordinary drill used 7.5 kg of sunflower / hectare .

El-Awad (2003) in his evaluation of mechanical and manual sowing methods for cotton, sorghum and sunflower, reported that mechanical sowing reduced the seed rate of cotton, sorghum and sunflower by about 40, 33 and 17% respectively.

El-Awad (2005) reported that the use of planter saved about 8.0kg/hectare of cotton seeds, which is about 40% lower than that used with manual sowing method.

The effective field capacity is the actual output achieved by a machine. It is the function proportion to the machine width utilized, the travel speed and the amount of time lost in the field during the operation. The particular way to determine field efficiency is to determine the theoretical time required to cover an area and to compare this with the actual time taken (Omiama, 2004).

Hunt (1977) reported that the field capacity of an implement depends on its travel speed and one can expect drop in the field efficiency when the implement operating speed is increased.

El-Awad (2003) in his evaluation, mentioned that the time needed for manual sowing was 19 times that of mechanical sowing of sorghum.

Omiama (2004) reported that the rate of work varies according to equipment capacity, operator ability, field and crop conditions.

Kathirvel *et al.* (2005) reported that by using pneumatic precision planter for sowing cotton, there was savings of 96.3% in time when compared to manual sowing.

Komi (2005) reported that manual sowing resulted in significantly higher cost, which was found to be 42% higher than the machine operating cost. Additionally, the saving in cost of the treated seed and the thinning operation that required for the manual sowing.

This research was intended to evaluate different planting methods with the use of two different planting machines in comparison with the manual sowing with regard to their overall performance through systematic laboratory and field tests. This evaluation is focusing on seed rate, plant emergence, plant population, spacing between plants, and yields, besides to find out fuel consumption, actual field capacity and efficiency of the two planters.

MATERIALS AND METHODS

The experiment was conducted during the season of 2004/2005 at University of Gezira Farm, in the Gezira State at latitude 14' 24" N, longitude 33' 30" E, while in 2005/2006 the experiment was carried out at the Gezira Scheme, Taiba Block, Massad site at Gezira State.

Two planters were used, pneumatic planter and belt type planter and compared with manual sowing. In order to achieve the objective of this research, the following variables were selected: Three different sowing methods were considered, which were: Pneumatic planter (P1), Belt planter (P2) and Manual sowing (Ms). Three levels of tractor forward speeds were chosen to determine planter performance with the speed, which were: S1 of 3.8 km/hr (using light gear with the first speed), S2 of 7.5 km/hr (using light gear with the second speed) and S3 of 11 km/hr (using heavy gear with the fourth speed).

Experimental design was a completely randomized block design with four replications, to accommodate seven treatments, which were two planters (pneumatic and belt), each with three levels of forward speed blues manual sowing method as control.

The field lay out of the experiment occupied an area of about 1.25 hectare, which divided into four blocks, each block represent a replication. The seven treatments of the sowing method were randomly distributed in each block. The area of each plot was 3.2 x138 meter, with the pass way in the middle of the area for the tractor movement.

Laboratory test was carried to determine the planters performance with different seed rates for spacing between plants of 5, 10 and 15cm.

Sorghum (variety Tabat) was used. Better graded seed of uniform size and shape, which separated many times was chosen. Then the germination tests were carried for these seeds, which resulted in 95% germination percentage.

Different parameters were evaluated in this test. Machine Parameters: Planter seed rate (kg/ha, Actual filed capacity (ha/hu), Field efficiency (%) and Fuel consumption (Lit/ha).

Plant parameters; Plant spacing (cm), Plant population (1000/ha). Crop biomass (dry matter) ton/ha. Grain yield (ton/ha).

The planters had been prepared and calibrated to assure the accuracy of different seed rates. The tractor and the two planters had been subjected to general check as well as the proper attachment between the implement and the tractor, according to their instructions for use in their operator manual.

RESULT AND DISCUTION

The effects of different sowing methods on seed rates were evaluated (Table .1, and Figure .1). In the first season, the average seed rates of the two planters were similar and amounted to 5 kg/ha. However, manual sowing resulted in 15 Kg/ha. Similar results were obtained in the second season Table .2.

The analysis of variance showed very high significant difference (P=0.001) in the seed rates between the different sowing methods, It was found that planters resulted in the lower seed rates. This was mainly due to the high precisions of the metering device of the two planters, compared to the uncontrolled number of seed per hole in manual sowing, where more than three seeds per hole were dropped. This agreed with Pothecary (1968), El-Awad (2003), Komi (2005) and EL-Awad (2005). The use of planter saved about10 Kg/ha of seeds, which is about 66.7% lower than that used with manual sowing method.

The analysis of the results showed that the change of the forward speed of planter did not change the seed rates obtained, which agreed with the results obtained by Babier (1982), Wanjura and Hudspeth (1968) and Komi (2005).

The effective field capacity was evaluated for different sowing method (Table .1 and Figure .2). In the first season, the average effective field capacity achieved by pneumatic and belt planter was found to be similar and amounted to 1.8 ha/h. However, manual sowing resulted in 0.08 ha/h. The same results were obtained in the second season (Table 2.). The analysis of variance showed very high significant difference (P=0.001) in the effective field capacity between the different methods of sowing. This was mainly due to the low effective field capacity of manual sowing compared to the high effective field capacity of planters. The required average time for planter sowing was found to be 0.6 machine-h/ha, while manual sowing required an average time of 12.5 man-h/ha, which is about 21times the average time requirement for planter sowing. This agreed with Komi (2005) and El-Awad (2005).

The effective field capacity was very highly significantly (P=0.001) affected by the level of the planter speeds. This is because the effective field capacity is a function proportion of the machine forward speed. The increase in the machine forward speed will decrease the actual working time required. This agreed with Omiama (2004), who stated that increasing the forward speed will increase the production of the machine.

Field efficiency was evaluated for the two planters (P1 and P2) at different speeds for the two seasons (Table .1 and Table 2). The mean efficiencies for the two planters were found to be similar and equals to 76% for the two seasons. The analysis of variance for two seasons, showed that there were no significant differences between the two planters with regard to field efficiency at different speeds.

The effects of changing planters forward speed on field efficiency for the two seasons indicated that as the forward speed increased the field efficiency decreased but the differences were not significant. This because the effective operating time is decreased, while the time losses will remain the same or will not drop by the same rate in operating time, so mathematically the field efficiency will be less. This agreed with the findings of Hunt (1977) and Omiama (2004).

The fuel consumption for the two planters was found to be similar for the two seasons and amounted to about 4 Lit/ha (Table .1 and Table 2). The fuel consumption per hectare increased with decreased planter speed, which indicated that more operation time was needed to cover the area, compared with the high speed level. Therefore, more fuel will be required per hectare in the case of low speed as compared with high speed level, but the differences were not significant.

Table .1 : Sowing method performance of machine parameters for the first season

Treatment	Seed rate (kg/ha)	Effective field capacity(ha/hr)	Field efficiency(%)	Fuel consumption (Lit/ha)
P1 at 3.8 km/h	4.7	0.94	78	4.0
P1 at7.5km/h	4.8	1.83	76	3.6
P1 at11 km/h	5.0	2.60	75	3.3
P2 at3.8 km/h	5.0	0.92	77	4.0
P2 at7.5km/h	4.9	1.83	76	3.5
P2 at11 km/h	4.9	2.59	75	3.3
Manual sowing	15	0.08	-	-
Mean	6.3	1.5	76	3.6
SE ±	0.70	0.17	0.56	0.17

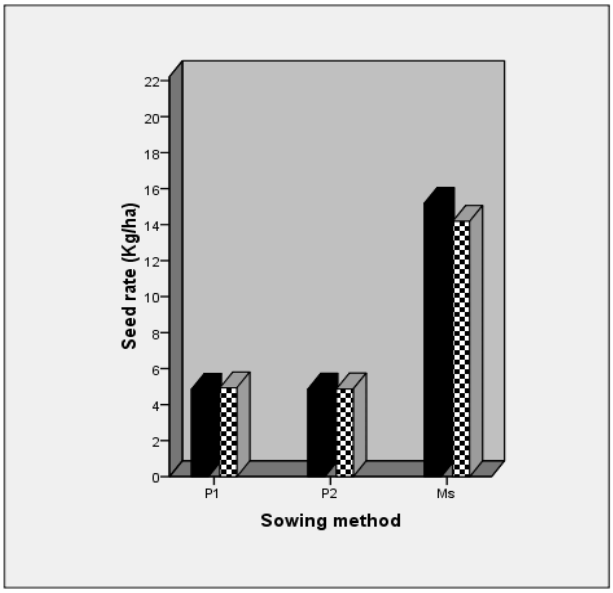
5% LSD	10.1	0.71	-	-
CV %	58.7	60.0	3.6	16.9
Sig.	***	***	NS	NS

Note :
P1= Pneumatic planter. P2= Belt planter.
NS= Not significant at the 0.05 significance level.
*** =Significant at the 0.001 significance level.

Table .2 : Sowing method performance of machine parameters for the second season

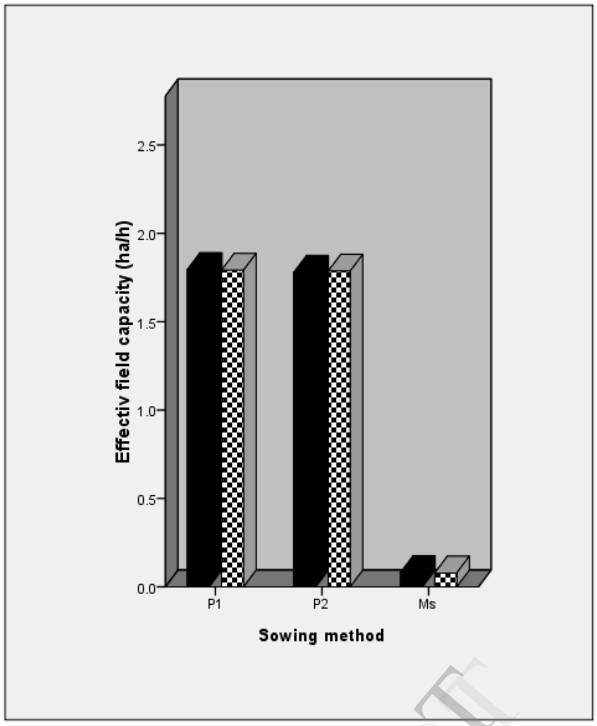
Treatment	Seed rate (kg/ha)	Effective field capacity(ha/hr)	Field efficiency(%)	Fuel consumption (Lit/ha)
P1at 3.8 km/h	4.9	0.94	78	4.1
P1at7.5km/h	4.8	1.84	77	3.6
P1at11 km/h	5.1	2.60	74	3.4
P2 at3.8 km/h	5.0	0.92	77	4.1
P2 at7.5km/h	4.8	1.83	76	3.7
P2 at11 km/h	4.9	2.61	75	37.
Manual sowing	14.2	0.08	-	-
Mean	6.2	1.5	76	3.8
SE ±	0.63	0.17	0.62	0.13
5% LSD	9.1	0.76	-	-
CV %	53.2	60.0	4.1	12.4
Sig.	***	***	NS	NS

Note :
P1= Pneumatic planter. P2= Belt planter.
NS= Not significant at the 0.05 significance level.
*** =Significant at the 0.001 significance level.



P1= pneumatic planter	1st Season
P2= belt planter	
Ms= manual sowing	2nd Season

Figure (1): Effects of sowing method on seed rate



P1= pneumatic planter	1st Season
P2= belt planter	
Ms= manual sowing	2nd Season

Figure (2): Effects of sowing method on effective field capacity.

Plant parameters

The results of number of plants emerged/ha after 7 days from the first irrigation, are shown in Table (3). In the first season, the average number of plants emerged/ha for pneumatic (p1), belt planter (p2) and manual sowing were found to be 105000, 96000 and 220000 plants/ha, respectively, while in the second season (Table 4.), the respective values, were found to be 101000, 96000 and 224000 plants/ha. The analysis of variance for the two seasons showed that there was very high significant difference (P=0.001) between the sowing methods. This could be attributed to the high precision of the pneumatic planter. The pneumatic planter supplied with rubber tires gauge wheels for each unit, which considered as a good depth control devices. The depth control device adjusts the furrow depth to the desired and uniform planting depth, while the press wheels firm the soil around seeds imparting a proper pressure over seeds.

This resulted in maximizing water uptake and decreasing the soil strength above the seed and fastened germination. On the other hand, the belt planter consisted of spring-loaded press wheel that carrying a portion of the machine, and used to drive the metering system of each unit. Moreover, it has no effective provision mechanism for adjusting the press wheel. Therefore, too much pressure may be exerted over the seeds, which might resulted in pushing seeds deeper, thus, delaying plant emergence. This was in line with the results obtained by Komi (2005).

The results obtained also showed that the planters resulted in rapid and even emergence of the seedlings than the manual method. The manual sowing resulted in poor emerged plants percentage compared to the actual seed rate used. This was probably due to the uneven seed depth in the case of the manual sowing, thus, some seeds might be placed in a too shallow depth that suffered from low moisture to germinate or it might not be firmed well with the soil and thus resulting in reduced seed-soil contact or it might be washed with the irrigation water. In some cases the seed might be placed too deep, resulting in delaying plant emergence. These results were in line with the findings of Pothchery (1968) who stated that planting with machines give more even germination than manual methods.

The results of plant spacing of different sowing methods are displayed in Table (3) and Table 4., for the two seasons the mean plant spacing for pneumatic planter (p1) and belt planter (p2) found to be similar and amounted to 10 cm, while manual sowing resulted in 35 cm. The analysis of variance for the two seasons showed that there were very high significant differences (P=0.001) between the methods of sowing with regard to plant spacing. The machine sowing resulted in a narrow spacing between plants within the row than the manual sowing. The spacing between holes for manual sowing was found to be about 71% wider than the machine sowing. The wider spacing was required in case of manual sowing, so as to reduce the effect of competition between plants. This coincided with the findings of Pothecary (1968) and Komi (2005). The statistical analysis for the two seasons, indicated that there was no significant difference between the two types of machine (p1) and (p2) with regard to plant spacing. However, the plant spacing was not significantly affected by changing planter forward speed. This was due to the constant ratio between the speed of metering device and the planter forward speed. So the metering speed device was directly related to the planter forward speed, this coincided with the findings of Babeir (1982), Singh *et al*. (2004) and Komi (2005).

The results obtained for the plant population/ha with different sowing methods are shown in Table (3). In the first season, it was found that the mean plant population/ ha for pneumatic planter (p1), belt planter(p2) and manual sowing was 110000, 109000, 137000, respectively, while in the second season (Table 4.), the respective values were found to be103000, 101000 and 143000 plants/ha, respectively. The analysis of variance for the two seasons showed that there was very high significant difference (P=0.001) between the methods of sowing with regard to the plant population. Compared to the planter sowing, manual sowing produced the higher plant population, although thinning operations was done. This agreed with Pothecary (1968) and El-Awad (2003). Further more, the analysis of variance for the two seasons showed no significant difference in plant population between the two types of planter and planter speed. This was expected, because the two planters were considered as the precision planters, which imply accurate seed rate and spacing of single seed within the row. This agreed with the laboratory test results that obtained previously.

The results obtained for grain yield with different sowing methods are indicated in Table (3). The average grain yield for pneumatic (p1) and belt planter (p2) was found to be similar and amounted to 3.4 (Ton/ha). However, manual sowing resulted in 3.0 (Ton/ha). Compared to manual sowing, planter resulted in about 13.3% increase in grain yield. This was

attributed to high competition between plants for the available resources compared to the planter sowing (single seed per hole). This agreed with the findings of El-Awad (2003)

The analysis of variance showed no significant differences in grain yield between the different sowing methods. This was due to the fact that the crop have a long range of plant population without any significant influence on the productivity.

The results obtained for crop biomass with different sowing methods are displayed in Table (3). It was found that the average crop biomass for pneumatic planter (p1), belt planter (p2) and manual sowing was 3.8, 3.6, and 3.2 (Ton/ha), respectively.

The analysis of variance showed that there was a high significant difference (P=0.003) in crop biomass between different sowing method. The average crop biomass yield of manual sowing was found to be lower than that of the planter sowing. This was due to the competition between plants with manual sowing compared to the machine sowing, which resulted in adequate stand.

Table 3: Sowing method performance of plant parameters for the first season

Treatment	Crop emergence (1000 /ha)	Plant spacing (cm)	Plant population (1000 /ha)	Grain yield (Ton/ha)	Crop biomass (Ton/ha)
P1 at 3.8km/h	104	10.0	111	3.5	3.8
P1 at 7.5km/h	107	10.0	109	3.4	3.8
P1at11 km/h	103	10.0	110	3.2	3.9
P2at 3.8 km/h	97	10.0	112	3.8	3.9
P2 at 7.5km/ h	97	11.0	107	3.2	3.5
P2 at11 km/h	93	10.0	109	3.3	3.5
Manual sowing	220	35.0	137	3.0	3.2
Mean	117	13.7	113	3.3	3.6
SE ±	8.14	1.66	2.20	0.08	0.06
5%LSD	9.3	24	25.1	0.6	0.6
CV %	36.8	64.2	10.3	12.0	8.3
Sig.	***	***	***	NT	**

Note :
NS = Not significant at the 0.05 significance level.
** = Significant at the 0.003 significance level
*** = Significant at the 0.001significance level.

Table 4: Sowing method performance of plant parameters for the second season

Treatment	Crop emergence (1000 /ha)	Plant spacing (cm)	Plant population (1000 /ha)	Grain yield (Ton/ha)	Crop biomass (Ton/ha)
P1 at 3.8km/h	104	10.0	104	3.6	3.7
P1 at 7.5km/h	97	10.0	104	3.5	3.9
P1at11 km/h	102	11.0	101	3.3	3.9
P2at 3.8 km/h	93	10.0	105	3.6	3.7

P2 at 7.5km/ h	96	10.0	102	3.4	3.5
P2 at11 km/h	100	10.0	98	3.2	3.5
Manual sowing	224	33.0	143	3.2	3.7
Mean	116	13.5	108	3.4	3.7
SE ±	8.58	1.60	3.17	0.07	0.06
5%LSD	11.5	22.5	37.2	0.6	0.6
CV %	39.1	63.0	15.6	12.0	8.3
Sig.	***	***	***	NT	**

Note :
NS = Not significant at the 0.05 significance level.
** = Significant at the 0.003 significance level
*** = Significant at the 0.001significance level.

Operational cost

The costs of machine and manual sowing were shown in Table 5. for the two seasons. Planter sowing resulted in lower seed cost of 12.14 SDG/ha compared to 38.10 SDG/ ha for manual sowing in the first season. The reduction in seed cost with the use of planter was amounted to 68% and 65% compared to manual for the first and second season, respectively. This indicated that machine sowing saved the cost of the seeds. This agreed with the findings of Zaidi *et al.* (1993) and El-Awad (2003).

Table 5. shows that the means of planter sowing operation cost was 19 SDG/ ha, while the manual operation cost was 26 SDG/ha. The machine sowing cost was 27% lower than that of the manual sowing.

Moreover, manual sowing was followed by the cost of thinning operation, which was not true with planter sowing. This indicated that planter sowing reduced the cost of sorghum production. This agreed with the findings of El-Awad (2003) and Zaidi *et al.* (1993).

Table 5. operational cost

Method of sowing	Seed rate (kg/ha)		Seed cost (SDP/ha)		Operation cost (SDP/ha)		Thinning cost (SDP/ha)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Means of machine sowing	5	5	12	5	19	19	5	19
Means of manual sowing	15	14	38	14.	26	26	15	26

*** Note: SDP Sudanese Pound**

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