International Journal of Environment, Agriculture and Biotechnology
Vol-7, Issue-4; Jul-Aug, 2022

Journal Home Page Available: https://ijeab.com/
Journal DOI: 10.22161/ijeab

Peer Reviewed

The ASMC seeder improves maize sowing in the western region of Burkina Faso

Albert Barro[3*], Vinsoun Millogo[1,2], Begue Dao[1,2], Boureima Sayaogo[1,2], Toundji Olivier Amoussou[1,2], Michel Kéré[1,2], Robert Burdick[4], Timothy Harrigan[5]and Ajit Srivastava[5]

[1]Agriculture Innovation Lab, Appropriate Scale Mechanization Consortium (ASMC), Institute of Rural Development, Nazi Boni University, P.O. Box 01-1091 Bobo-Dioulasso 01, Burkina Faso

[2]Laboratoire de Recherche et d'Enseignement en Santé et Biotechnologie Animales, Institut du Développement Rural, Université Nazi Boni, 01 BP 1091 Bobo-Dioulasso 01, Burkina Faso

[3]Institut de l'Environnement et de Recherches Agricoles, 04 BP 8645, Ouagadougou 04, Burkina Faso

[4]Tillers international, 10515 OP Ave E Scotts, MI 49088, USA

[5]Department of Biosystems and Agricultural Engineering, Michigan State University, 524 S. Shaw Lane 120B, East Lansing, MI 48824, USA

*Corresponding author: altbarro@yahoo.fr; BP 10 Saria/Koudougou;
Tel: (00226) 70 10 03 10, E-mail address: altbarro@yahoo.fr

Received: 15 Jun 2022; Received in revised form: 05 Jul 2022; Accepted: 10 Jul 2022; Available online: 16 Jul 2022

***Abstract*— *In Burkina Faso, cultivation operations (tillage, sowing, weeding, fertilization, etc.) are mainly carried out by women and young people. Among them, sowing is a particular constraint that determines the success or failure of production. In this country, maize is grown by 78% of producers in the rainy season. In order to improve production, a simple seeder that can be made by local craftsmen was designed as part of the Appropriate Scale Mechanization Consortium (ASMC) project and evaluated with SR21 maize seed in the Koumbia region. It has been harnessed by two oxen. The equipment is evaluated on a plowed plot and on minimum tillage plot. Seed dimensions and distribution disc characteristics were measured. The characteristics of sowing, the traction force and the labor times were measured and compared with those of manual sowing. The results indicate that the sowing time is 3.6 to 3.8 h ha^{-1}, i.e., 8 to 10 times faster than manual practice. The traction force is 22.6 kgf (226 N). That is available for oxen hitch even with one animal. Seed calibration can improve tool performance. The tool has great potential for increasing production if the other production inputs are assured.*

***Keywords*— Seeder, traction force, labor time, maize SR21, plowing**

I. INTRODUCTION

World agricultural production comes mainly from small farms which supply 80% of the products (FAO, 2011). Actors in the agricultural sector are mainly women and young people who are involved in farming activities (tillage, sowing, weeding, fertilization, etc.) as well as in harvesting and post-harvest. Among these activities, sowing is a particular constraint for the producer because it largely determines the success or failure of field production, and itsintensive labor. In the conditions of the Sahel where the rains are irregular at the start of the season, one of the resilience strategies of producers is to carry out the maximum area of sowings during the favorable period. In more arid conditions in the center and north of the country, direct seeding is used. It is imperative to increase cereal production in order to supplied the food needs of growing populations. As the natural resources of this Sahelian zone are limited, the sustainable intensification of cereal production must be an important option (FAO, 2017).

The results of work in 1985 and 1986 on sowing millet with super-eco tool using animal draught in Senegal showed the importance of this tool for agricultural production (Havard, 1988). In Burkina Faso, this sowing method is more recent, and currently oriented towards direct sowing in the context of conservation agriculture (Cissé, 2013). In recent years, the difficulties encountered by farmers in obtaining labor, particularly because of gold panning, have led them to take an increasing interest in mechanization in general and particularly that of sowing (Lhoste *et al.*, 2002).

In the western region of the country, maize represents a third of the total consumption of cereals (FAO, 2014). Its cultivation is practiced by 78.6% of farms in the rainy season (DPSAA, 2010). In order to improve productivity, a simple seeder that can be made by local craftsmen has been designed as part of the Appropriate Scale Mechanization Consortium (ASMC) project. This study was carried out to evaluate the effectiveness of this equipment in the realization of maize sowing as well as it impacts on the production of this crop in farmers' fields in Koumbia region.

II. MATERIEL AND METHODS

2.1 Study site

The study is carried out in the rural commune of Koumbia (11° 14' 11" North, 3° 41' 47" West), located in the province of Tuy which is in the "Hauts Bassins" region. It is located 67 km northeast of the city of Bobo-Dioulasso. It is bordered to the north by the commune of Houndé, to the south by the commune of Karangasso Vigué, to the west by the commune of Lena and to the east by those of Founzan, Guéguéré and Bondigui (Fig. 1). It has 14 administrative villages.

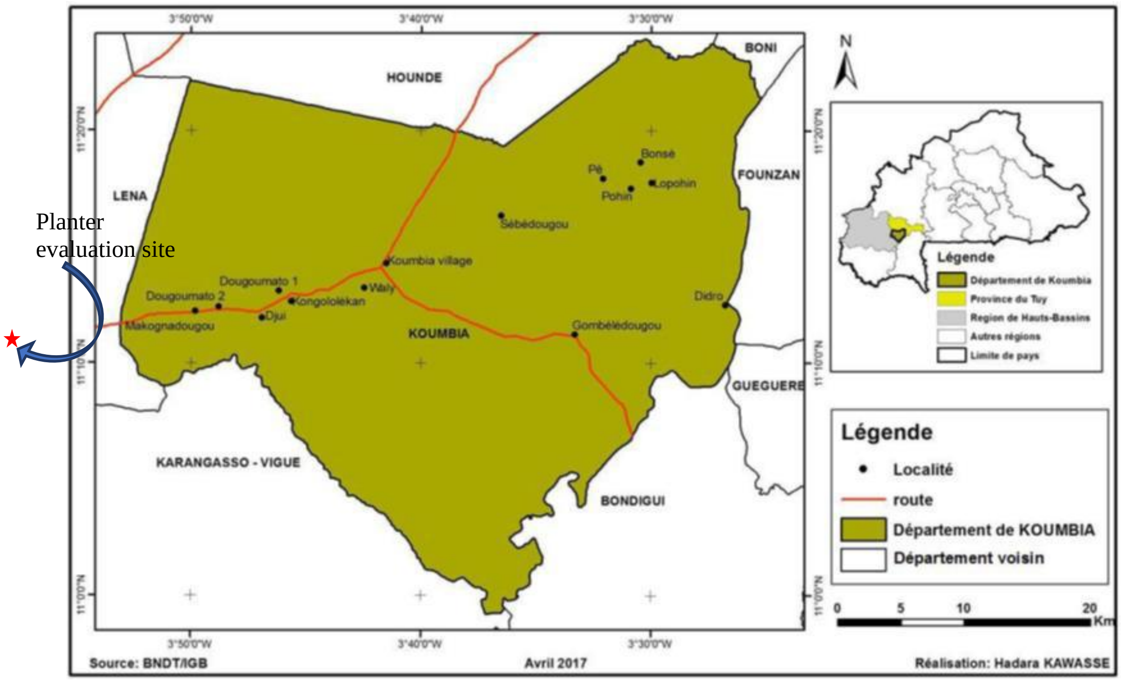


Fig.1: The study site Location (Koumbia)

2.2 Climate and vegetation

The climate is the Sudanian type (Fontès and Guinko, 1995) characterized by the succession of a wet and dry seasons. The rainy season goes from May to October.The average rainfall is around 800 mm to 900 mm as shown by the evolution of rainfall over the last ten years in the commune (Fig. 2).

The most common species are*Acacacia albida, Adansonia digitata, Azadirachta indica, Gmelina arborea, Manguifera sp. Parkia biglobosa, Byturospermum parkii, Anogeissus leocarpus, Lannea acida, Lannea microcarpa, Terminalia avicennoides, Piliostigma thonningii, Zizuphus mauritiana, Prosopis africana, Pterocarpus erinaceus*.Along the streams is dominated by *Mitragyna inermis, Cordia myxa, Nauclea latifolia*. The soils of the department of Koumbia are ferric lixisol on sandy or sandy-clayey materials (FAO, 2006).

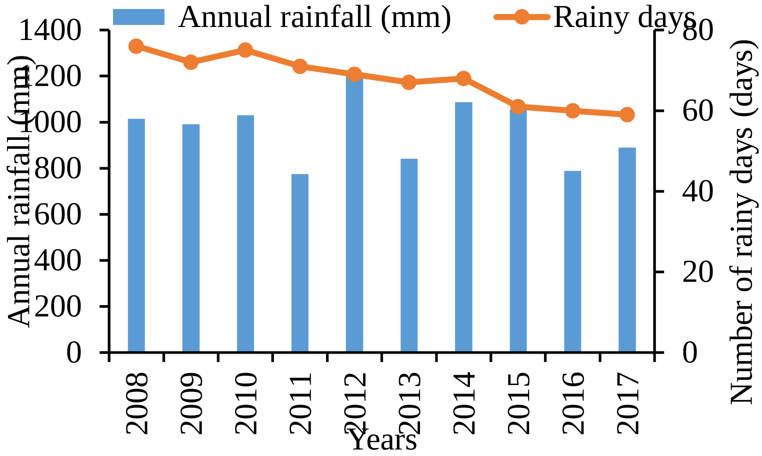


Fig.2: Rainfall over ten consecutive years

2.3 The ASMC maize seeder

The seeder is of the single-row and single-seed type. The theoretical spacing between seed holes is 20 cm. It is animal drawn tool (oxen or donkeys). It can be manufactured by the local craftsmen. It has a hopper that contains a seed distribution disc. This distribution disc is driven by two driving wheels at the front. At the rear there is a press wheel for slightly compacting the soil on the seeds after the opener share and the skimmers close the pits (Fig. 3). In the case of the tests, the animal used is oxen. The theoretical sowing depth is 5 cm.

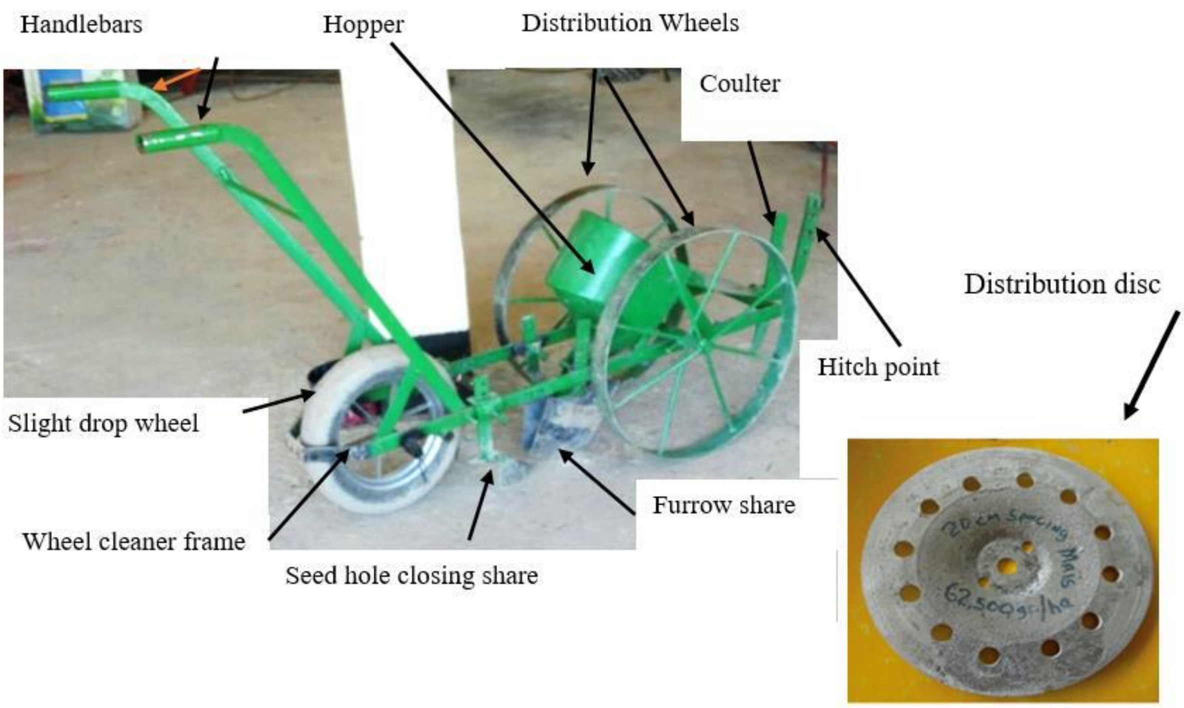


Fig.3: Photography of ASMC maize seeder

2.4 The seed used

The crop seed used is maize's (*Zea mays* L.), variety SR21. It is streak resistant with a potential grain yield of 5.1 t.ha^{-1}. Its sowing maturity cycle is 95 days. The weight of 100 seeds varies from 25 to 33.4 g (Sanou, 2013). The usual seed quantity is 19 kgha^{-1}.

2.5Measurements and observations

- The SR21 maize seed are measured according to the following pattern (Fig. 4).

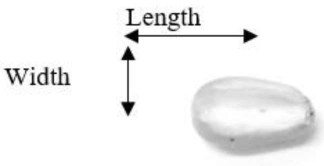


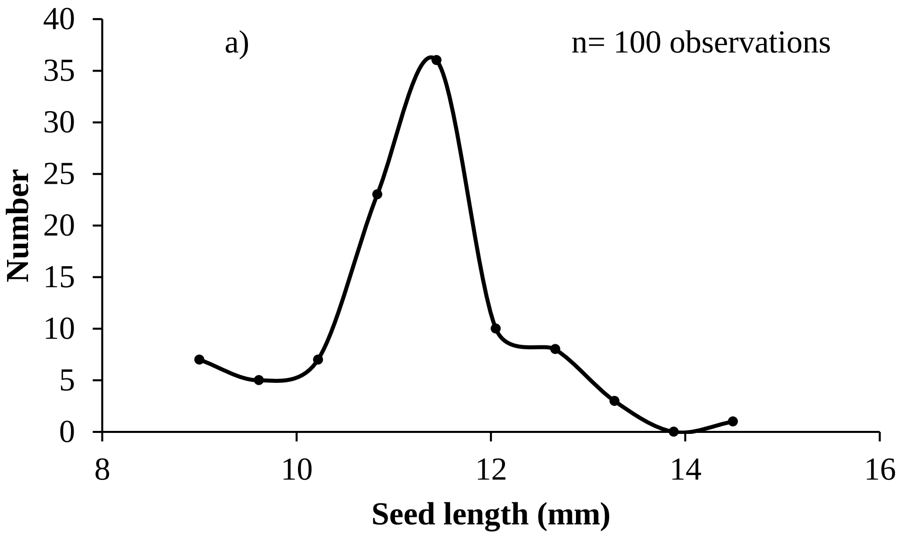
Fig 4:Maize SR21 seed size measure pattern

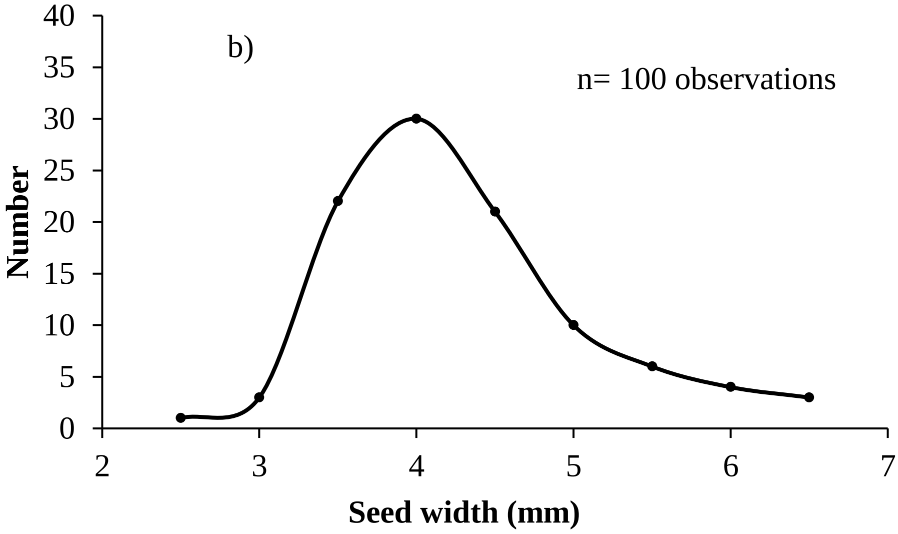
- The spacing between pits is measured between two pits taken at random. The number of observations is 20.
- The number of seeds in the hole is observed on 20 holes.
- The dimensions of the seed distribution disc holes are measured on two old seed distribution disc and one new seed distribution disc.
- The sowing labor time is measured on each elementary plot in four repetitions.Manual sowing is carried out by 7 people and mechanized sowing is done by one seeder and hitch.
- The traction force with a two-oxenhitches measured by 231observations.

III. REsultS

3.1Maize SR21 seed size observed

The measured SR21 maize seeds show that the dimensions are on average 10 to 12 mm in length, 3 to 5 mm in width and 3 to 5 mm in thickness. (Fig 5 a, b, c). This is indicated on graphic a), b) and c).





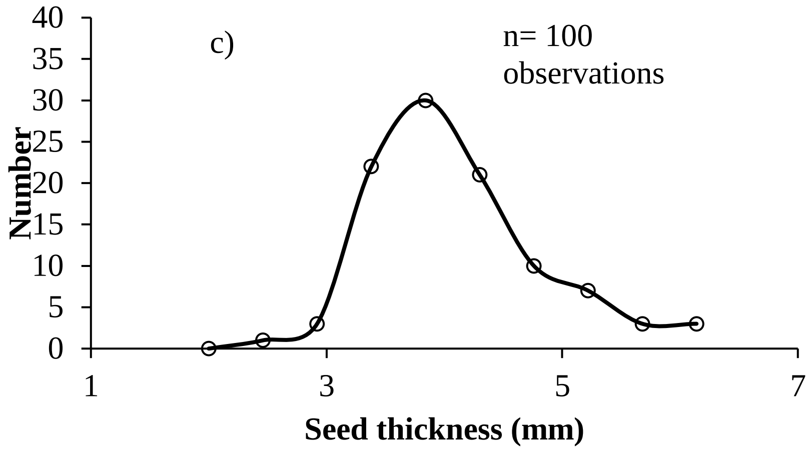


Fig.5: Maize SR21 seeds sizes -a) seed length b) seed width; c) seed thickness.

3.2 The seeds distribution during sowing

The observation of the arrangement of the seed is presented in Table 1. The seed is sown in pits with an average distance of 27.21 cm. The standard deviation between the pits is 13.11 cm. this indicates that in the plot there are pits, 40.32 cm apart and other very close ones only 14.10 cm apart. For the number of seeds per pit, observations indicate that the value is 1 to 2 seeds (Table 1).

Table 1: Seed placement parameter value

Parameter	Mean value	Standard deviation
Distance between pits(cm)	27.21	13.11
Number of seeds by pit	1.24	0.47

n= 20 observations

3.3 Holes size on distribution discs

The results of the analysis of variance indicate that the average depthof the holes of the seed distribution disc are different with a probability $P<0.0001$ for $n= 12$. The old version of the seed distribution disc has holes of 4 mm depth than that for the new version the holes have an average of 5 mm (Fig. 6). For the holes diameter of the seed distribution disc there is also a very highly significant difference between the means. For the old version, the holes have a diameter of 13.5 mm while for the new version the holes have a diameter of 13.3 mm (Fig. 7).

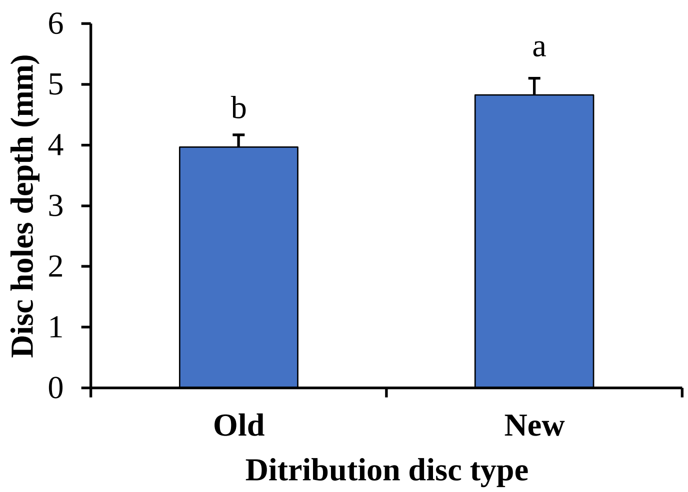


Fig.6: Seed distribution disc holes depth

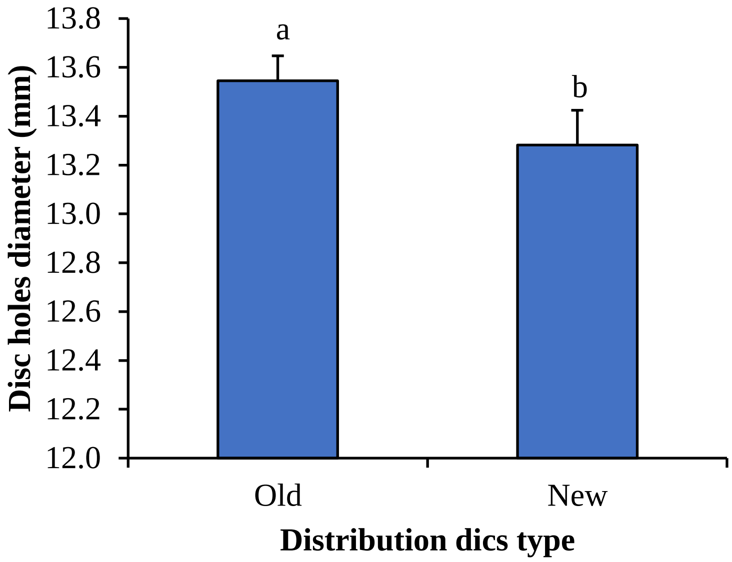


Fig.7: Seed distribution disc holes diameter

a and b indicate different groups of means.

The traction force

Traction force with a cattle hitch varied from 10 to 40.6 DaN. The average is 22.6 ± 6.4 DaN. The number of observations is 235 (Fig. 8).

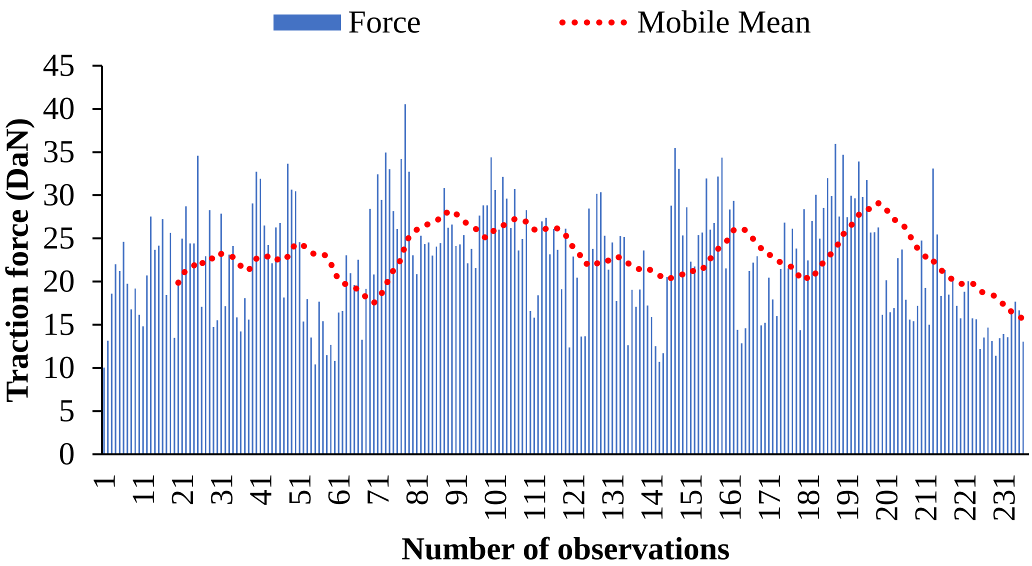


Fig.8: Traction force variation during sowing operation

Mobile mean:20 mobile means of traction force

3.4 Labor time of sowing

The analysis of variance shows that there is and highly significant difference between the average times taken by manual sowing compared mechanized one with the ASMC seeder on the plots of plowing. The probability is 0.001.For minimum tillage plot there is a significant difference between manual and mechanized sowing. The probability is 0.015. It is 0.001 for mechanized sowing with the ASMC seeder and manual sowing. The interaction between the two factors is also highly significant with P = 0.009.

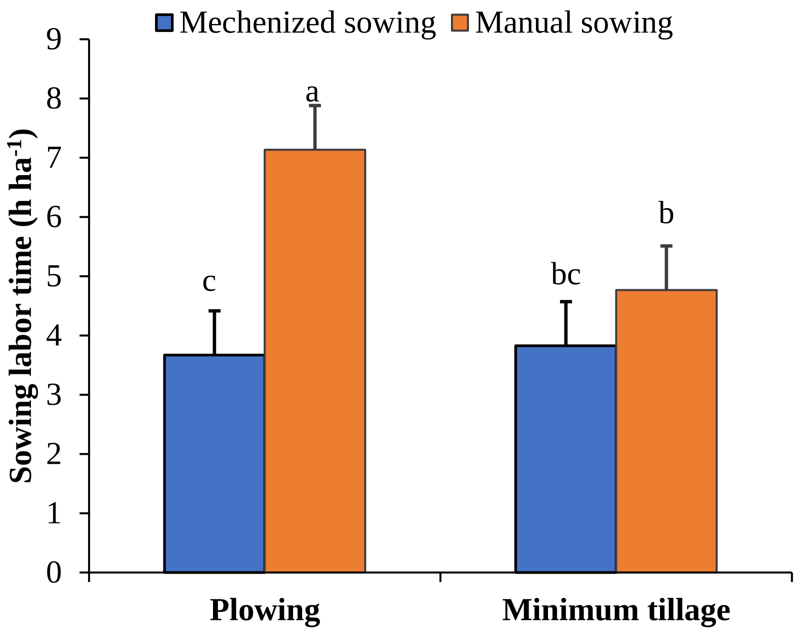


Fig.9: Time taken for sowing on the plots

IV. DISCUSSION

4.1 Seeds distribution by seeder discs

The measurement of the dimensions of the seeds of SR21 maize shows that it has an average length of 11.44 mm and a width of 4 mm for a thickness of 4 mm. The diameter of the seed distribution disc is for the old model is 13.55 mm for a depth of 3.97 mm; for the new seed distribution disc these dimensions are 13.28 mm and 4.82 mm. In 2015, the sowing tests carried out on SR21 maize with the FITARELLI direct seeder with animal traction gave a sample of one seed per pit (Coulibaly *et al.*, 2015). The seederseed distribution disc holeshad diameters of 12.5 and 13.5 mm. The results obtained here are similar to this observation. The old seed distribution disc has a smaller space for taking maize seeds, (169 mm^3). This allows a maize seed to enter the seed distribution disc laterally. Another seed can only enter it upright with little hold on it by the seed distribution disc due to the fact that the inclination of the seed distribution disc in the hopper is approximately 45° (Fig. 3). The new seed distribution disc model had 201 mm^3;20% more volume. This is what led to the significant deposit of seeds in the pit (Sayaogo, 2018; Millogo *et al.*, 2020).

4.2 Seed placing during sowing and crop density

The seeds are sown in the plots at a spacing between pits of 27 cm. This is greater than the theoretical distance of 20 cm. The variation in this distance is significant. The standard deviation represents 48% of the average distance between pits obtained in the field. There is then a problem with the operation of the equipment. With a distance of 20 cm between pits and one seed per pit for sowing 80 cm between rows, the theoretical density would be 62,626 plantsha^{-1}. With a spacing of 20 cm between pits and 60 cm between row Kandlil *et al.*, 2017 obtained the best production in Egypt in the Nil delta. In Koumbia, the pedoclimatic conditions differ, the best production is given by sowing at spacingof 27 cm between pits and 80 cm between rows (Sayaogo, 2019). With the spacing between pits obtained of 27 cm for a sowing of 1 seed per pit, the density is 46064 plantsha^{-1}. This density value is close to that of Fitsum (2018) with the animal-drawn seeder which obtained a density of 45,000 plants ha^{-1} on maize in Ethiopia. But with 1.24 as the average there will be 57119 plants in the best case. This is different from the recommended density of 5000 to 6000 plants per hectare. If the dose of fertilizer is always the same as that popularized, i.e., 200 kg of NPKha^{-1} and 100 kg of ureaha^{-1}, the plants in the plot have more potential nutrients than in conventional production systems. Grain and straw production could be improved.

4.3 The times taken for sowing on the plots and traction force

The time taken for sowing is shorter with the ASMC seeder. It varies from 3 h 42 min to 3 h 48 min whether it is on plowing or minimum tillage for 1 ha. For manual sowing, this time is 7h 06 min when sowing is done on plowing with 7 people for 1 ha. The same operation carried out on the plot of minimum tillage; the time is then 4h 48mn with 7 people. The labor time is then 49 h 48 min 33 h 36 min per ha for manual sowing on plow plot and minimum tillage plot respectively. The difference in time between sowing on the plowing plot and sowing on the minimum tillage is mainly due to the fact that on plowing plot the mobility of the operators more difficult. But mechanized sowing is then 9 to 13 times faster than manual operation. These data are in agreement with those found by Barro *et al.* (2014). This represents a significant time saving in the cropping calendar at this critical phase for producers. The traction force measured during sowing operations indicates that it has a low value. Indeed, according to Vall, (1998) an ox can provide in continuous traction force 10 to 15% of its weight in continuous traction force. According to Millogo *et al.* (2020) draft oxen in the western region have live weight ranging from 227 to 297 kg. The traction force measured during sowing at relatively low values (22.6 DaN on average) makes the seeder usable by a large number of producers using animal traction, whether with cattle or donkey teams. The use of appropriate maize production technology with seeding densities and adequate nutrient supply can increase yields and producer incomes (Lal and Indoriya, 2016). Indeed Sayaogo, (2019) showed that the plants were more vigorous with a grain production of 2780 kg ha^{-1} in the producer's field.

V. CONCLUSION

The ASMC seeder is a tool that allows the producer to sow maize faster than manual practice. On a plowing plot, the seed drill takes 4 hha^{-1} while manual practice takes 33.6 h ha^{-1} for a man. On a plot with minimum tillage, the labor time is 5 hha^{-1} with the seeder, whereas it is 50 h ha^{-1} with manual practice. The required tractive force for the 22.6 daN seeder is available for hitches in the region. The old is shallower than the new. Maize seed must be calibrated to increased seeder efficacity. The use of the ASMC seeder allows the producer to sow 8 to 10 times more area than that carried out manually. Improving other cropping operations will significantly increase maize production, for the western region and all Burkina Faso.

ACKNOWLEDGMENT

The authors of this article would like to thank USAID for funding this work, which was done as part of the Appropriate Scale Mechanization Consortium ASMC Project. This project is part of the activities of the intensification laboratory (SIIL, Sustainable Intensification Innovation Lab). Our thanks go to the Producer for their collaboration.

REFERENCES

[1] FAO (Food and Agriculture Organization of the United Nation).(2011). La situation mondiale de l'alimentation et de l'agriculture 2010-2011. Le rôle des femmes dans l'agriculture : Combler le fossé entre les hommes et les femmes pour soutenir le développement, Rome, Italie.

[2] FAO. (2017). The future of food and agriculture – Trends and challenges. Rome Italie, 180p.

[3] Havard M. (1988). Les conclusions des expérimentations (1950-1985) sur les semis en culture attelée des principales espèces cultivées. *Machinisme Agricole Tropical*101 : 11-51.

[4] Cissé T. (2013). Analyse des effets de la mécanisation, du semis direct sous couverture végétale et de l'association culturale sur les besoins en main d'œuvre et la gestion de l'enherbement dans la Région du Centre-Nord du Burkina Faso. Mémoire d'Ingénieur en Vulgarisation Agricole, Institut du Développement Rural, Université Polytechnique de Bobo-Dioulasso, Burkina Faso, 58 pages.

[5] Lhoste P, Baudoux S, Vall E. (2002). Fiche n° 12 sur la traction animale en régions chaudes : instruments polyvalents utilisés avec l'animal de trait. In : Mémento de l'agronome. CIRAD, GRET, France-MAE. Montpellier : CIRAD, 1 Cd-Rom ISBN 2-86844-130-0

[6] FAO.(2014). A regional strategy for sustainable agricultural mechanization: Sustainable mechanization across agri-food chains in Asia and the Pacific region. G. Mrema, P. Soni & R. Rolle. FAO Regional Office for Asia and the Pacific Publication 2014/24. 74 pp.

[7] DPSAA (Direction de la Prospective et des Statistiques Agricoles et alimentaires), 2010. Résultats définitifs de la Campagne Agricole 2009/2010. MARHRH/SG/DGPER/DPSAA, Ouagadougou 104p

[8] Fontes J and Guinko S. (1995). Carte de la végétation et de l'occupation du sol du Burkina Faso. Note explicative. Ministère de la coopération française, Toulouse, France.

[9] Sanon P. (2013). Étude diagnostique de la mécanisation du semis en traction animale dans les Hauts-Bassins : Cas des villages de kourouma, koumbia et gombélédougou. Mémoire d'Ingénieur d'Agriculture, Centre Agricole Polyvalent de Matourkou, Burkina Faso, 63 pages.

[10] Coulibaly K, Sanon P, Sanogo L, Dabiré D, Havard M, Andrieu N. (2015). Utilisation du semoir de semis direct à traction animale FITARELLI sur maïs. Fiche technique n°46 ABACO CIRDES Burkina Faso, 3p. https://www.researchgate.net/publication/331824819

[11] Sayaogo B.(2018). Test du semoir à traction animale conçu et développé par le projet de mécanisation agricole appropriée pour optimiser le semis du maïs. Mémoire

d'ingénieur du développement rural option agronomie UNB-IDR Bobo Dioulasso. 81p.

[12] Fitsum A. (2018). Development and evaluation of animal-drawn, single row tillage-cum-multicrop planter. *Academic Research Journal of Agricultural Science and Research (ARJASR)* Vol. 6(8), pp. 500-508, October 2018 DOI: 10.14662/ARJASR2018.083

[13] Millogo V, Kéré M, Amoussou OT, Nikiema R, Barro A, Harrigan T, Burdick R, Ouédraogo G A**.**(2020). Évaluation de la force et de la vitesse de travail des bœufs de trait à l'aide d'un dynamomètre numérique en début de campagne agricole au Burkina Faso, *Tropicultura* 2295-8010 volume 38 (2020) Numéro 2, 1535.

[14] Kandil A A, Sharief A E, Abozied A M A. (2017). Maize Hybrids Yield as Affected by Inter and Intra Row Spacing.*International Journal of Environment, Agriculture and Biotechnology (IJEAB)* Vol-2, Issue-2, Mar-Apr- 2017. http://dx.doi.org/10.22161/ijeab/2.2.11 ISSN: 2456-1878

[15] Barro A.(2014). Effet de la densité et du décalage de la date de semis du niébé (Vigna unguiculata L. Walp) sur les performances agronomiques et économiques de l'association maïs (Zea mays L.)/niébé en situation réelle de culture dans les villages de Koumbia et Gombêlêdougou (Burkina Faso). Mémoire de Master en Production Végétale. Institut du Développement Rural, Université Polytechnique de Bobo-Dioulasso, Burkina Faso, 54 pages.

[16] Vall E. (1998). Capacités de travail du zébu, de l'âne et du cheval au Nord-Cameroun. Concept d'adéquation du couple animal-outil.*Annales de Zootechnie*, **47** (1) : 41-58.https://doi.org/10.1051/animres:19980103

[17] Lal RS and Indoriya DS.(2016). Effect of Integrated Nutrient Management on Yield of Maize (Zea mays L.)*International Journal of Environment, Agriculture and Biotechnology (IJEAB)* Vol-1, Issue -4, Nov-Dec- 2016. http://dx.doi.org/10.22161/ijeab/1.4.28 ISSN: 2456-1878