Black Sea Journal of Agriculture
doi: 10.47115/bsagriculture.1401132

Open Access Journal
e-ISSN: 2618 – 6578

Research Article
Volume 7 - Issue 2: 163-167 / March 2024

DEVELOPMENT OF BALER MACHINE FOR HUMID AREAS

Tuğba KARAKÖSE[1]*, Kemal Çağatay SELVİ[1]

[1]*Ondokuz Mayıs University, Faculty of Agriculture, Department of Agricultural Machinery and Technologies 55139, Samsun, Türkiye*

Abstract: Baler machines collect the swath straw when it reaches a sufficient level of moisture and bale it. However, the drying time of the material is prolonged in humid regions. This causes the land not to be used for the second crop and to get wet again in case of rainfall. Clogging is observed in commonly used baling machines when baling these products because they are more humid. The study aims to collect and bale the material even if the straw is not sufficiently dried in humid areas. For this purpose, dimensional improvements were made in the stubble chopper unit of a baler and compared with two widely used machines in the country. While clogging was observed in the other machine, no clogging was observed in the improved machine. In terms of direct usability, feed with particle size distribution smaller than 15 cm was 93.20% for the developed machine (DM) and 89.43% for the baler machine (BM-1). DM clogging problems have not been observed.

Keywords: Baler machine, Stubble chopper unit, Square straw bale

***Corresponding author:** Ondokuz Mayıs University, Faculty of Agriculture, Department of Agricultural Machinery and Technologies 55139, Samsun, Türkiye
E mail: tugba.karakose@omu.edu.tr (T. KARAKÖSE)
Tuğba KARAKÖSE https://orcid.org/0000-0002-1725-7027
Kemal Çağatay SELVİ https://orcid.org/0000-0002-9133-5046

Received: December 6, 2023
Accepted: January 27, 2024
Published: March 15, 2024

Cite as: Karaköse T, Selvi KÇ. 2024. Development of baler machine for humid areas. BSJ Agri, 7(2): 163-167.

1. Introduction

Feed, which is important in animal nutrition, is gaining value day by day for farmers engaged in the production of animal foodstuffs. Feed storage is important in terms of increasing feed prices and ensuring the sustainability of animal feeding. After harvesting forage crops, natural drying is impossible at the desired level due to the minimal number of sunny days, especially in regions with annual rainfall averages above 1000 mm. This can lead to storage out of the appropriate humidity conditions and partial deterioration of the product obtained. In terms of forage quality and suitable storage conditions, the moisture content of the harvested forage plants is reduced to 15-20%. However, care should be taken not to lose valuable parts such as leaves and flowers by drying the forage plants more than necessary during drying (Ulger, 1982).

Ensuring energy balance and efficient functioning of the immune system in animals is possible with adequate and balanced nutrition. This can be achieved by increasing forage consumption as early as possible with appropriate ration arrangement at the beginning of lactation. Increasing feed consumption can be achieved by using quality roughages, well-balanced quality concentrate feeds, suitable feeding areas, clean feeders, preventing stressful conditions (shower, fan, etc.) and taking timely measures to minimize imbalances in the rumen (roughage ratio, roughage particle size, etc.) (Görgülü et al., 2011). For this reason, particle size distribution of forages is important. It is reported that the chopping and grinding of grass, stalks, and straw loses flavor and digestibility. In excellent grinding, bacterial fermentation of cellulose cannot be completed because the size of the forage particles causes the feed to pass through the rumen rapidly. As a result, the degree of cellulose digestion in feeds decreases and most of the cellulose and similar substances are thrown out with manure as undigested (Akyıldız, 1986). On the other hand, insufficient particle size decreases the ruminal acetate-to-propionate ratio and the pH, which, in turn, lowers the milk fat percentage (Lammer et al., 1996). In forages with large piece sizes, problems such as difficulty in consuming these forages are encountered. Accordingly, the feeding of forages with a reduced particle size (RFPS) has been suggested earlier in the context of potentially enhancing dry matter intake (DMI) in conventional dairy cattle feeding (Haselmann et al., 2019). For example; in silage plants with low dry matter content, it is reported that it would be appropriate to chop them into pieces with an average length of 4 cm (Yalçın and Çakmak, 2005). It is recommended that the particle size ratio should be between 1.27 and 5.08 cm for feeding hay to animals as feed (Bitra et al., 2011). To prevent these problems, the most appropriate feed piece sizes are between 1-5 cm. If the hay is given directly, it is recommended to be no more than the size of the mouth. Green forage crops follow operational processes such as harvesting, mowing, crushing, barrelling, mixing, drying in the field, and baling. Balers are machines that collect many materials such as green forages, stubble, various animal feeds, cereal stalks from the field in scattered or swath form, compress them and bale them by tying them with rope or wire (Güner and Keskin, 2011). The product arriving at the stubble chopper unit is compressed and tied in the bale room. The bale is thrown out of the channel. In this process, many factors such as the condition of the field surface, the condition of the hay, the size and uniformity of the windrows, the capacity of the picking up and feed mechanisms, the forward speed of the baler, the amount of power available affect the efficiency of the baler (Verma et al., 2019). Besides these factors product to be baled and its moisture condition is also very important. If the product moisture cannot be brought to suitable conditions according to the product and moisture condition, situations such as mold may be encountered during storage. However, the moisture condition varies regionally. Under the conditions of our country, the product to be baled can be baled at the beginning of the summer period such as June in non-humid regions, while in humid regions, this period can see the end of the summer period such as August. In humid regions, product moisture cannot be reduced below 20%. This hinders agricultural activities or causes delays. In humid regions, to continue agricultural activities in the summer months, bales may have to be collected even if they are not at the appropriate moisture level for storage. This situation may cause clogging problems in the collection and sizing units in humid areas during baling.

The extremely limited number of rain-free days required for drying and baling the barrels makes this process difficult. This study aims at the dimensional and functional development of a stubble chopper unit that can collect the product even if the product moisture is at the desired optimum levels in baling machines, as well as to solve the clogging of the collecting unit and to chop the product.

2. Materials and Methods

The experiments were conducted in Salur village (40.99349262069505, 35.90112034879492) in Ladik district of Samsun province (Figure 1) on a land that is flat and partially sloping (4%).

Figure 1. View of the terrain

The tractor was operated up and down the slope. Wheat straw was used as material. In measurements taken from different points in the field, the swath width was between 90-120 cm and the swath height was between 25-40 cm. The moisture content of the straw was determined by the standard oven method and its value was 19.2%.

The studies were carried out with three different baler machines; It was carried out with a) developed machine (DM), b) baler machine 1 (BM-1) and c) baler machine 2 (BM-2). BM-1 and BM-2 are commercially produced and are already widely used by farmers. DM, on the other hand, is a machine developed on the stubble chopper unit and produced commercially. This development was designed by changing the dimensional characteristics of the stubble chopper (straw chopping rotor) unit of a baler machine.

The pickup unit widths of the three machines were measured as 155 -170 cm. The stubble chopper unit has been redesigned with dimensional changes (Figure 2). This design has been tested on DM. While the diameter of the stubble chopper unit in BM-1 and BM-2 type balers, which are widely used in the market, is 20.8 cm, this diameter has been changed and this diameter value has been enlarged in DM. Since the patent application process for the DM machine is ongoing, this measurement value cannot be given here. In addition, the counter-beater is made of 8 separate parts with different angles and is positioned to surround the beater with a total inclination of 170°. The spacing of the stubble chopper unit and the counter beater has been increased compared to BM-1 and BM-2, allowing the material that is more voluminous due to excessive moisture to be held by the stubble chopper unit. The number of metal sheets placed on the Stubble chopper unit was increased from 6 in normal machines to 7 in the DM machine.

In the baling process with these machines, the average bale dimensions were 35×45×80 cm, while the bale weight was between 20-25 kg. For piece sizes, samples taken from the bale were divided into pieces smaller than 5 cm, between 5-15 cm and larger than 15 cm and weighed with a precision scale and determined as a percentage value.

The study was conducted according to the random parcel factorial trial design with 2 factors and 16 replications. Three different machines and 2 different tractor speeds (3.5 km h^{-1} and 5 km h^{-1}) were used as factors. Tractor speeds were determined by traveling 100m in the convenient gear.

The results were evaluated by analysis of variance in the SPSS 19.0 Program. The differences between the averages were determined according to the LSD test. However, during the work, the BM-2 type machine was constantly clogged and was found to be unsuitable for use. Therefore, the results of only two machines were evaluated.

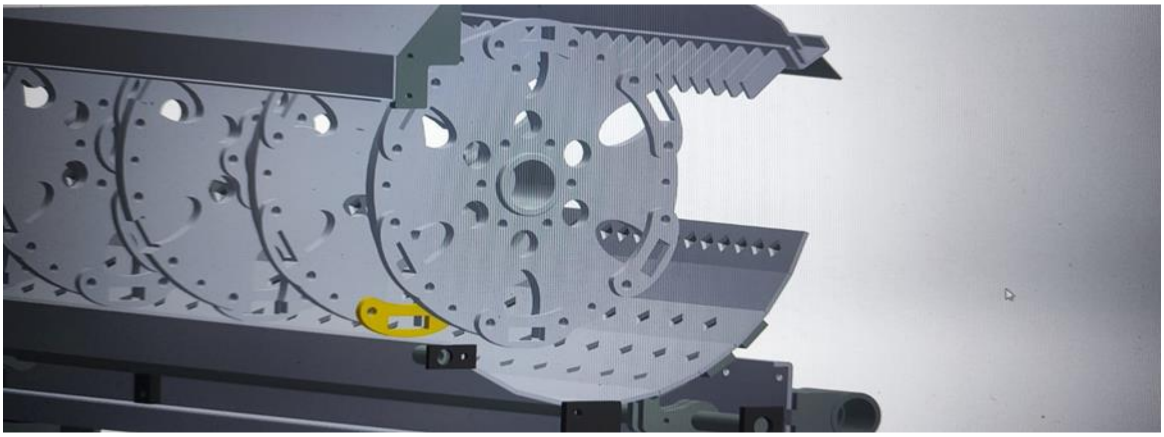

Figure 2. General view of the developed Stubble chopper unit.

3. Results and Discussions

The machine and other machines developed to solve the product collection and baling problem seen in humid regions were evaluated statistically.

Statistically, machine and speed factors were found to be significant for part sizes smaller than 5 cm and between 5-15 cm (P<0.05). However, it was found to be statistically insignificant for fragment sizes larger than 15 cm (P<0.05). Mangaraj S. And Kulkarni S.D. (2011) reported in their study that the particle size ratio larger than 15 cm in wheat straw was 58%. They found that the average length was 29.56 cm. Re-grinding is needed for this value in terms of animal nutrition. In cases where this value cannot be reduced, some difficulties may occur in terms of nutrition, especially in cattle. This causes the feed to be ground again, increasing operating and feed costs. In our study, it was determined that the feed rate larger than 15 cm varied between 1-65-12.47% for DM and 3.70-17.81% for BM-1. It was observed that the developed machine's part size value greater than 15 cm (6.80%) was lower than the other machine (10.56%) (Table 1).

Table 1. Effect of some factors on particle size

	x<5 cm	5<x<15	15<x
Machine			
DM	35.48[a]	57.72a	6.80 b
BM-1	39.92b	49.51b	10.56 a
Speed			
3.5 kmh^{-1}	42.63 a	49.18 b	8.18 a
5 kmh^{-1}	32.77 b	58.04 a	9.18 a
LSD Value			
Machine	3.33	2.81	1.98
Speed	3.33	2.81	ns
Machine × Speed	4.71	3.98	2.80
R^2	0.56	0.67	0.36
CV	0.17	0.10	0.45

ns= not significant

According to the results of the analysis of variance, the interaction between DM and BM-1 with speed was found to be significant when the fragmentation size was less than 5 cm and between 5-15 cm. For DM 3.5kmh^{-1}, the fragment sizes smaller than 5cm and between 5-15 cm varied between 30.65-45.67%, 46.17-65.63%, respectively, while for BM-1, these values varied between 26.45-63.70% and 32.59-54.14%, respectively. For DM 5kmh^{-1}, it varied between 21.54-40.61%, 51.93-72.49% for fragment sizes smaller than 5cm and between 5-15 cm, respectively, while for BM-1, it was found between 21.08-44.41%, 44.09-62.65% (Figure 3). The findings of this study differ from those reported by El-danasory and Imbabi (1998) in the context of wheat straw harvesting using a combine machine. The latter authors asserted that the feed rate increases with an increase in forward speed. However, in the present research, this pattern held for DM and BM-1 in the distribution of particle sizes between 5 and 15 cm, while the opposite was observed for particles smaller than 5 cm. It appears that the nuanced process of harvesting smaller-sized straw, coupled with structural differences between the combine and baler, accounts for this disparity in results. Another study on equipping a conventional combine available in the market with a two-stage turbine designed for wheat straw collection showed a 50% feeding rate. This change resulted in an additional collection of 0.84 tons/ha of straw (Suardi et al., 2020). However, it is noteworthy that more losses were observed compared to the baler developed in the present study; especially in particle sizes between 5-15 cm and under two different tractor speeds.

According to variance analysis, the combined effects of machine and speed were significant for part dimensions (P<0.05). When the Machine x speed interaction was evaluated together, part size less than 5cm was important for BM-1 (44.84%) and DM (40.41%) at 3.5kmh^{-1}. Considering the 5-15 cm piece size, it has been determined that DM is important at 5kmh^{-1} speed. If these pieces are smaller than 5 cm in size, this may cause the bale to disintegrate. However, the baling process with piece sizes in the range of 5-15 cm has a positive effect on the bales not being easily dispersed. Statistical analysis for two methods of feeding in conventional rectangular balers shows that the ideal speed of the tractor during feeding is 4 km/h (Afify et al., 2005). Other results have been observed regarding the direct effect of tractor speed on straw harvesting efficiency. In the harvesting of rice straw, elevating the baler's forward speed from 2 to 4 kmh^{-1} and from 4 to 6 km/h resulted in a respective reduction of 30% and 26% in the overall baling costs. Additionally, a decrease in the baler's feeding rate was observed with an increase in the forward speed (Afify et al., 2002). In another study conducted by Verma et al., 2019, the highest feeding efficiency (93.47%) was achieved using a round straw baler designed for various straw types, particularly emphasizing paddy straw. This optimal performance occurred under conditions of minimal moisture (19-21%) and maximum tractor speed (0.3 kmh^{-1}). The results of the current study, demonstrating a feeding rate of 93.20% for the baler specifically designed for wheat straw harvesting, emphasize the suitability of this device for application on both national and international levels.

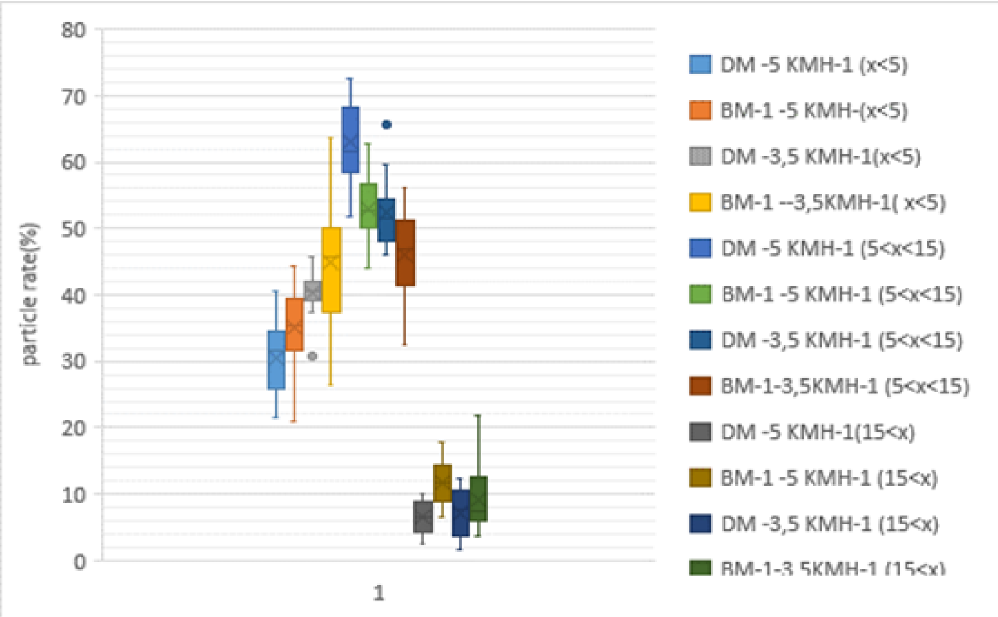

Figure 3. Part size distribution (%).

4. Conclusion

The fact that the particle size ratio larger than 15 cm does not exceed 6.58% increases the direct usability of the feed without re-grinding. Therefore, significant reductions in operating expenses and feed costs can be achieved. In terms of direct usability, while feeds with particle size distributions smaller than 15cm were 93.20% for DM, this value was 89.43% for BM-1. It was observed that the bales made between DM and BM-1 did not show any difference in size and mass. It was observed that the product loss did not exceed 1% during the machine operation, and there was no binding loss or damaged bale. In the developed machine, no clogging was observed in the collection and harvesting unit during operation. However, blockages occurred in the other machine. For the developed machine, work successes at average speeds of 3.5 km h^{-1} and 5km h^{-1} were 340 bales h^{-1} and 420 bales h^{-1}, respectively. For the other machine, the work success was 3.5 km h^{-1} and 5km h^{-1}, with an average of 276 bales h^{-1} and 332 bales h^{-1} respectively. In practice, it has been observed that the main source of this difference is the frequent blockages in BM-1. It is also important that the bale has appropriate piece sizes to ensure direct feed delivery and reduce the energy needed to break down the feed. In practice, the changes made to the stubble chopper unit, specifically aimed at improving DM during baling, have provided visible advantages over baling with BM-1. The use of such machines is important in terms of important factors such as time, cost and quality.

Author Contributions

The percentage of the author(s) contributions is presented below. All authors reviewed and approved the final version of the manuscript.

	T.K.	K.Ç.S.
C	50	50
D	60	40
S	90	10
DCP	50	50
DAI	60	40
L	70	30
W	60	40
CR	50	50
SR	60	40

C=Concept, D= design, S= supervision, DCP= data collection and/or processing, DAI= data analysis and/or interpretation, L= literature search, W= writing, CR= critical review, SR= submission and revision.

Conflict of Interest

The authors declared that there is no conflict of interest.

Ethical Consideration

Ethics committee approval was not required for this study because there was no study on animals or humans.

References

Afify MT, Bahnasawy AH, Ali SA. 2002. Effect of rice straw picking up method on the performance of a rectangular baler. The AIC 2002 Meeting CASE/SCGR program Saskatoon, July 14-17, Saskatchewan, Canada, pp: 14-17.

Afify MT, Bahnasawy AH, Ali SA. 2005. Effect of rice straw feeding on the performance of rectangular baler. Egypt J Agri Engin, 22(2): 380-403.

Akyıldız A.R. 1986. Yemler bilgisi ve teknolojisi. Ankara Üniversitesi Yayınları, no:974, Ankara, Türkiye, pp: 32.

Bitra VS, Womac AR, Yang YT, Miu PI, Igathinathane C, Chevanan N, Sokhansanj S. 2011. Characterization of wheat straw particle size distributions as affected by knife mill operating factors. Biomass Bioen, 35(8): 3674-3686.

El-Danasory MM, Imbabi AT. 1998. Study of mechanical and manual pickup and baling of wheat straw after harvesting with combine. Egypt J Agri Engin,15(2): 246-260.

Görgülü M, Göncü S, Serbester U, Kıyma Z. 2011. Süt sığırlarının üremesinde beslemenin rolü. 7. Ulusal Zootekni Bilim Kongresi, 14-16 Eylül, Adana, Türkiye, ss: 9-39.

Güner M, Keskin R. 2011. Hasat harman makinaları. Ankara Üniversitesi Yayınları, no:302, Ankara, Türkiye, ss: 98-100.

Haselmann A, Zehetgruber K, Fuerst-Waltl B, Zollitsch W, Knaus W, Zebeli Q. 2019. Feeding forages with reduced particle size in a total mixed ration improves feed intake total-tract digestibility and performance of organic dairy cows. J Dairy Sci, 102(10): 8839-8849.

Lammers B. P, Buckmaster D. R, Heinrichs A. J. 1996. A simple method for the analysis of particle sizes of forage and total mixed rations. J Dairy Sci, 79(5): 922-928.

Mangaraj S, Kulkarni S. D. 2011. Field straw management–a techno economic perspectives. J Insti Engin, 8(1-2): 153-159.

Ülger P. 1982. Tarımsal makinaların ilkeleri ve projeleme esasları. Ankara Üniversitesi Yayınları, no:605, Ankara, Türkiye, ss: 312.

Suardi A, Stefanoni W, Bergonzoli S, Latterini F, Jonsson N, Pari L. 2020. Comparison between two strategies for the collection of wheat residue after mechanical harvesting: Performance and cost analysis. Sustainability, 12(12): 4936.

Verma K, Shrivastava A, Gautam A. K. 2019. Performance evaluation of tractor drawn round straw baler for paddy. Pharma Innov J, 8: 846-849.

Yalçın H Çakmak B. 2005. Bazı kaba yemlerin sıkıştırılabilirlik özellikleri. Ege Üniversitesi Bilimsel Araştırma Projesi Kesin Raporu Proje 2005 01-ZRF:42, İzmir, Türkiye, ss: 125.