Effect of row spacing and cutting times on forage yield in some sorghum varieties (sorghum bicolor L. Moench)

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ABSTRACT:
The experiment was carried out to study forage yield of sorghum varieties (Sorghum bicolor L. Moench) as affected by Row spacing and Cutting. This experiment was conducted at Grda-Rasha Research Station - College of Agriculture - Salahaddin University - Erbil, during summer season (2015)

A split-split plot within Randomized complete block with three replicates was designed. Three varieties of sorghum (Rabih, Anqath and Kaffir 2) allocated in the main plots and three row spacing (30, 45 and 60) cm was allocated in sub plots, while cutting frequency (cutting once and cutting twice ) laid as in sub- sub plot which done . Each replication consists of 18 treatment units.

The studied characters were: leaves/stems ratio, total green forage yield (t ha⁻¹) and total dry forage yield (t ha⁻¹). The results of this study can be summarized as following: Rabih recorded green and dry forage (95.09, 22.20) t ha⁻¹ respectively, as well as highest Leaves/stems ratio (0.66), and had stable forage yield at cutting frequency. Planting at 30 cm row spacing exhibited superiority for total green and dry forage yield for all varieties. The green forage yield at 30 cm row spacing (100.79) t ha⁻¹ and dry yield was (23.67) t ha⁻¹, Comparing to the forage green and dry yield at 60 cm row spacing which were (55.50) and (12.41) t ha⁻¹ respectively. Cutting once gave highest green and dry forage yield (86.71, 20.20) and (65.07, 14.35) t ha⁻¹ except Rabih variety which showed highest green forage yield at cutting twice (136.66).

KEY WORDS: sorghum variety; forage yield; cutting period; row spacing.
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1. INTRODUCTION:

Sorghum uses as forage are grown in many semiarid regions due to excellent growing habit, high yield potential and better nutritive value (Saini, 2012). Malik et al. (2007) and Dahlberg et al. (2008) make sign, because of the diversity and availability of sorghum germplasm resources, the sorghum breeder has been accomplished to improve sorghum production globally. Bakheit (1990) manifested the yield and its components of (200) germplasm; there were differences in plant height, leaf area index and yield and its components. The differences were found between two sorghum varieties P931 and P956 in number of days to 50 % flowering (Sang et al., 1991).

Mahmud et al. (2003) clarified that Hagari variety produced taller plants, greater stem diameter and higher fodder yield as compared to JS 263. Sharif et al. (2015) compared among three cultivars of sorghum are Speed feed, Payam and Sepideh they showed that fresh weight was the highest in speed feed and the lowest Sepideh cultivar, while the highest plant height was the Sepideh cultivar and the lowest plant height in Payam cultivar. The comparison means of these cultivars showed that plant height was the highest in Sepideh cultivar (101.76 cm) and the lowest in Payam cultivar (89.86 cm).

AL- Edelbi et al. (2015) evaluated 17 genotypes of (Sorghum bicolor L. Moench). The results showed significant differences among
genotypes in fodder yield characters, the range was between (21.43 to 70.72) t ha⁻¹.

Fouman (2010) reported that eight sorghum cultivars were assessed to determine the most suitable traits. A comparison of means indicated that the highest green fodder and lowest green fodder were (186.8 and 137.2) t ha⁻¹ respectively as for dry matter yield Sweet Jumbo cultivar mean was the highest (39.21 t ha⁻¹). Malik et al. (2007) determined that fodder yield in sorghum is mainly affected by row spacing and seeding rate. Yield increases from narrow rows due to better light interception and more efficient water use (Scott et al., 1999). Three row spacing (15, 30 and 45 cm), three seeding rates (50, 60 and 70) kg ha⁻¹ and their effect on fodder yield of sorghum was studied by (Malik et al., 2007). The yield was significantly decreased with increasing row spacing. The greatest fodder yield was recorded at seeding rate (75 kg ha⁻¹) at highest seed rate and narrow 15 cm row spacing, while lowest green fodder yield obtained by lowest seeding rate (50 kg ha⁻¹) and highest row spacing 45 cm. Aysen et al. (2004) also referred that seeding rate showed significant effect on dry matter, yield and most yield components.

Orak and Kavder (1994) obtained greatest yield from highest seed rate and narrow spacing. Mokadem et al. (2002) showed that increasing row spacing reduced the yield. Miko and Manga (2008) explained the closest intra-row of 25 cm gave 35.06 and 38.59 % increase in yield at two season over the widest spacing of 75 cm. Snider et al. (2012) studied the row spacing and seeding rate effect on biomass production, they found that narrower row spacing 19 cm produced the highest biomass. Increasing seeding rate did not affect yield; while stem diameter declined. Atis et al. (2012) compared forage sorghum cultivars to determine effects of harvesting at four different growing stage on the change in yield and forage quality they found that suitable harvesting time of forage sorghum is physiologic maturity stage (PM) for high yield and fodder quality. Lowest yields are obtained when the crop is harvested at flowering stage. Afzal et al. (2012) revealed for first, second and third cuttings showed significant differences at all growth attributes, plant height (193.92, 195.24 and 192.79 cm) in first, second and third cutting respectively. Sharifi et al. (2015) used three cultivars Speedfeed, Payam and Speiden comparison of cultivar means showed fresh weight was the highest in speed feed cultivar (73.59 g / plant) and the lowest in Speiden cultivar. Hussein et al. (1979) and AL-Fahdawi (2011) found that increase in dry matter may be referred to the late growth stage lead to hard stem and accumulation of dry matter as a result to the decreases in leaves to stem ratio comparing to early growth stage when plant is fresh.

Aims of this study, we are using agronomical practices as different row spacing and cutting frequency and effect on the yield of green and dry forages of three varieties of sorghum

2. Martials and methods
The study was conducted at Gerda–Rasha Research Station, College of Agriculture/ Salahaddin University (Lat 36° 11' 356" N, Long 44° 01' 987"; E, 418 meters Above sea level-MASL.), 5 km south of Erbil city during the autumn season of 2015 to study the effect of row spacing and cutting frequency on the forage yield of three varieties of sorghum (Sorghum bicolor L. Moench). Split spilt-plots design in completely randomized blocks arrangement, with three replications were used. Three varieties (Rabih, Anqath and Kaffir 2) were implemented in the main plots and three row spacing (30, 45 and 60 cm) distributed as sub plots, while the two cutting frequency (cutting once and cutting twice) represented sub-sub plots. Each replication consisted of 18 sub-sub plots (experimental units) of (1.5 m × 2 m), sowing depth was (4 – 5 cm) and plants were 10 cm apart within row to achieve 33333, 22222 and 166666 plants per hectare for three row spacing respectively. The sowing date was on June 5th, the both cutting frequency took place when 10-12 % of plant reach flowering stage. N P K (17:17:17) fertilizer at rate of 500 kg/ha was applied at sowing time and nitrogen fertilizer at the rate of 180 kg N/ha in the form of Urea (46 % N) to encourage the re-growth after cutting. All cultural practices were performed when it was necessary (Rathwan and Fakhr, 1976).

Studied characters:
Data were recorded for ten plants from mid row
Forage fresh weights were taken for 10 plants (stems, leaves and panicles) the weights were taken for each part separately.
1. Leaves/stem ratio.

\[
\text{Ratio} = \frac{\text{Total dry leaves weight (g)}}{\text{Total dry stems weight (g)}}
\]

2. Total forage fresh yield (t ha\(^{-1}\)).

Consist of total fresh (stems+ leaves+ panicles) g for 10 plants and converted to t ha\(^{-1}\).

3. Total forage dry yield (t ha\(^{-1}\)).

Total dry weight of (stems+ leaves+ panicles) g for 10 plants and converted to t ha\(^{-1}\).

2.2 Statistical Analysis.

The data analysis was conducted for all studied traits according to variance of analysis using the Statistical Analysis System (SAS Institute, 2005) program. Least Significant Difference test (L.S.D.) was used to compare between means at two levels of significant 0.05 and 0.01 (Al-Rawi and Khalaf-Allah, 1980).

### Table 1. ANOVA table for some characteristics of sorghum plant represented by Mean Square (MS)

| Source of variation (S.O.V) | Degrees of freedom (d.f) | Leaves/stem ratio | Green forage yield (t ha\(^{-1}\)) | Dry forage yield (t ha\(^{-1}\)) |
|-----------------------------|--------------------------|-------------------|-----------------------------------|---------------------------------|
| Replications                | 2                        | 0.001             | 76.17                             | 5.67                            |
| Varieties                   | 2                        | 0.144*            | 9106.85**                         | 523.97**                        |
| Error (a)                   | 4                        | 0.012             | 30.07                             | 11.65                           |
| Row spacing                 | 2                        | 0.016             | 9503.00**                         | 602.08**                        |
| Varieties × Row spacing     | 4                        | 0.001             | 525.03*                           | 49.17*                          |
| Error (b)                   | 12                       | 0.004             | 101.11                            | 9.15                            |
| Cutting frequency           | 1                        | 0.102*            | 6322.56**                         | 461.13**                        |
| Varieties × Cutting frequency | 2                      | 0.053             | 1422.42**                         | 5.63                            |
| Row spacing × Cutting frequency | 2                  | 0.015             | 30.50                             | 3.56                            |
| Varieties × Row spacing × Cutting frequency | 4 | 0.020 | 293.20** | 2.62 |
| Error (c)                   | 18                       | 0.020             | 43.44                             | 2.55                            |

* and ** Significant at 0.05 and 0.01 probability levels respectively.

3. Results and Discussions

3.1 Leaves/Stems ratio.

Only the varieties and cutting frequency showed significant differences Tab1. The significant difference was found among varieties from Tab.2. Rabih variety had the highest ratio (0.66), while Kaffir 2 variety had lowest ratio (0.48). That's mean Rabih variety produce the highest quality green fodder because the leaves contain protein and the mineral and decrease in fiber percentage (Khrbeet and Jasim, 2015 b). Cutting frequency had significant effect on leaves/stems ratio. The stem ratio increased at cutting twice because of losing the leaves and plant produce greater stem diameter. AL-Janabi and Aswad (2012) found that leaves/stems ratio reduce with progress to maturity because of losses in leave which lead to decrease in protein percentage.

### 3.2 Green forage yield (t ha\(^{-1}\)).

Tab. 1 revealed that highly significant differences were recorded among variety, row spacing, cutting frequency and the interactions of varieties × row spacing × cutting frequency and the interaction of varieties × cutting frequency, while significant interaction of varieties × row spacing was recorded. Tab.3 confirmed highly significant differences among varieties Rabih variety exceed as varieties in green forage yield (95.09) and
Kaffir 2 showed lowest green forage (51.14). These results are in agreement with Al-Takrety et al. (1992); Muhmud et al. (2003); Sharifi et al. (2015) they found highly significant differences among varieties in green forage yield. Concerning row spacing, the 30 cm row spacing exhibit the highest green forage yield (100.79), while 60 cm row spacing gave lowest yield of green forage (55.50). Many investigations obtained the same results. Orak and Kavder (1994); Gonzalez and Graterol (2000); Mokadem et al. (2002); Malik et al. (2007) and reported that green forage sorghum yield increased with narrow row. Scott et al. (1999) illustrated this results, referred to narrow rows have been better light interceptions and more efficient water uses. The cutting frequency showed highly significant differences in green forage yield, cutting once exceeding cutting twice in green forage yield (86.71 and 65.07) respectively. Highly significant difference due to the interactions of varieties × cutting frequency, Anqath variety showed highest green forage yield at cutting once, while Kaffir 2 variety its forage yield severely decline to 34.30 at cutting twice. The interaction varieties × row spacing showed significant differences for green forage yield. Rabih variety at 30 cm row spacing gave higher yield (130.18) follow by Anqath variety at 30 cm spacing row (104.60). The interaction of variety × row spacing × cutting frequency showed highly significant differences for green forage yield. Rabih variety at 30 cm row spacing at cutting twice had the highest green forage yield (136.66). Followed by Anqath variety at 30 cm spacing row in cutting once recorded 126.87. All varieties showed highest green forage yield when they cultivated at 30 cm row spacing and at cutting once and twice. We can notice that with increasing row spacing the forage yield decreased. These results are in agreement with Eric et al. (1995) who revealed that late maturity sorghum gave the highest green yield compared with early maturity variety. There were no significant differences between row spacing × cutting frequency.

### 3.3 Dry forage yield (t ha⁻¹)

Tab.1 showed highly significant effect of varieties, row spacing and cutting frequency, while the interaction between varieties and row spacing showed significant effect on dry forage yield. Rabih variety exceeded other varieties in dry forage yield it was (22.2), while Kaffir 2 variety had lowest dry forage yield (11.51) Tab4. These results were in accordance with AL-Tekrety et al. (1992) and Atasi et al. (2012) that manifested significant differences in dry matter yield among sorghum varieties. Highly significant differences in dry forage yield referred to row spacing effect. Highest dry forage yield (23.67) found at 30 cm row spacing and lowest yield (12.41) found at 60 cm row spacing. These results were comparable with Ayub et al. (2003) and Snider et al. (2012) they found that row spacing effect on biomass and narrow row produced highest biomass. The cutting frequency indicates, cutting once gave highest dry forage yield (20.20), while the cutting twice gave (14.35). A significant difference was observed according to the interaction variety × row spacing. The highest yield was given by Rabih variety cultivated at 30
cm row spacing (31.93). We notice that all varieties had highest dry forage yield when cultivated at 30 cm row spacing and lowest yield for all varieties found at 60 cm row spacing for all varieties.

4. Conclusion

Rabih variety recorded highest green and dry forage yield as well as highest Leaves/stems ratio. And had a stable forage yield at cutting frequency. Planting at 30 cm row spacing exhibited superiority for total green and dry forage yield for all varieties. Cutting once gave highest green and dry forage yield except Rabih variety which showed highest green forage yield at cutting twice when it’s planted at 30cm row spacing only.

Table 2: Effect of varieties, row spacing, cutting frequency and their interactions on leaves/stems ratio.

| Varieties | Row Spacing (cm) | Cutting Frequency | Means of cutting |
|-----------|-----------------|-------------------|-----------------|
| Rabih     |                 |                   |                 |
|           | 30              | Cutting once      | 0.56            |
|           |                 | Cutting twice     | 0.77            |
| Anqath    |                 |                   |                 |
|           | 30              | Cutting once      | 0.57            |
|           |                 | Cutting twice     | 0.56            |
| Kaffir 2  |                 |                   |                 |
|           | 30              | Cutting once      | 0.45            |
|           |                 | Cutting twice     | 0.52            |
|           |                 |                   |                 |
|           | 30              |                   |                 |
|           | 45              |                   |                 |
|           | 60              |                   |                 |
|           |                 |                   |                 |
|           |                 |                   |                 |
|           |                 |                   |                 |
|           |                 |                   |                 |
| LSD 0.05 |                 | n.s               |                 |
| LSD 0.01 |                 | n.s               |                 |

| Varieties × Cutting Frequency | Variety | Cutting once | Cutting twice |
|-------------------------------|---------|--------------|---------------|
| Rabih                         | 0.56    | 0.77         | 0.66          |
| Anqath                        | 0.57    | 0.56         | 0.59          |
| Kaffir 2                      | 0.45    | 0.52         | 0.58          |
| LSD 0.05                      | n.s     |              |               |
| LSD 0.01                      | n.s     |              |               |

| Row Spacing × Cutting Frequency | Row spacing (cm) | Cutting once | Cutting twice |
|---------------------------------|-----------------|--------------|---------------|
| 30                              | 0.52            | 0.55         | 0.66          |
| 45                              | 0.52            | 0.66         | 0.58          |
| 60                              | 0.54            | 0.63         | 0.61          |
| LSD 0.05                        | n.s             |              |               |
| LSD 0.01                        | n.s             |              |               |

| Means of cutting | 0.53 | 0.61 |
|------------------|------|------|
| LSD 0.05         | 0.08 |      |
| LSD 0.01         | n.s  |      |
Table 3: Effect of varieties, row spacing, cutting frequency and their interactions on green forage yield (t ha\(^{-1}\)).

| Varieties | Row Spacing (cm) | Cutting Frequency | Varieties × Row Spacing |
|-----------|------------------|-------------------|-------------------------|
|           |                  | Cutting once      | Cutting twice           |                         |
| Rabih     | 30               | 123.70            | 136.66                  | 130.18                  |
|           | 45               | 91.87             | 85.96                   | 88.66                   |
|           | 60               | 72.02             | 60.81                   | 66.41                   |
| Anqath    | 30               | 126.87            | 82.33                   | 104.60                  |
|           | 45               | 93.88             | 65.76                   | 79.82                   |
|           | 60               | 68.64             | 51.21                   | 59.93                   |
| Kaffir 2  | 30               | 88.75             | 46.41                   | 67.58                   |
|           | 45               | 58.83             | 32.52                   | 45.67                   |
|           | 60               | 56.35             | 23.98                   | 40.17                   |
| LSD 0.05  |                  | 11.31             |                         |                         |
| LSD 0.01  |                  | 83.36             |                         |                         |
| LSD 0.05  |                  | 12.65             | n.s                     |                         |
| LSD 0.01  |                  | 8.42              |                         |                         |

Table 4: Effect of varieties, row spacing, cutting frequency and their interactions on dry forage yield (t ha\(^{-1}\)).

| Varieties | Row Spacing (cm) | Cutting Frequency | Varieties × Row Spacing |
|-----------|------------------|-------------------|-------------------------|
|           |                  | Cutting once      | Cutting twice           |                         |
| Rabih     | 30               | 34.01             | 29.85                   | 31.93                   |
|           | 45               | 22.35             | 17.30                   | 19.82                   |
|           | 60               | 17.07             | 12.63                   | 14.85                   |
| Anqath    | 30               | 28.56             | 19.88                   | 24.22                   |
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