



EFFECT OF SOME AGRICULTURAL PROCESS ON GROWTH AND YIELD OF SORGHUM (*Sorghum bicolor* L.) (ARTICLE REVIEW)

Rayan. F. A. Al-Obady, Salim A. Y. Ghazal, Waleed K. S. Al-Juheishy

Department of Field Crops, College of Agriculture and Forestry, University of Mosul, Iraq.

ABSTRACT

Article information
Article history:
Received:1/11/2022
Accepted:9/12/2022
Available:31/12/2022

Keywords:

planting date, plant density, varieties

DOI:

<https://10.33899/magrj.2022.136718.1206>

Correspondence Email:

rayanobady79@uomosul.edu.iq

Sorghum is one of the important cereal crops and its importance is due to its multiple uses, as it is used in human food and animal feed in the form of concentrated grains or green fodder, as well as entering into many industries such as starch, cellulose, alcohol, brooms, baskets and many handicrafts and others. Sorghum is the most drought-tolerant summer field crop, but it is one of the crops that stresses the soil as a result of depleting many nutrients, especially nitrogen. Therefore, fertilization is necessary, especially nitrogen, which is reflected in improving the quality of forage and increasing the dry matter yield. The growth and yield of sorghum is affected by many environmental, genetic and agricultural factors, in which the growth and yield are the sum of the effect of these factors combined, and that following modern methods in serving this crop is one of the main factors in improving yield productivity, and the most important of these factors is determining the best cultivar and optimal planting date and the recommended plant density and the best fertilization rate that gives the best yield and the least cost and damage.

College of Agriculture and Forestry, University of Mosul.

This is an open access article under the CC BY 4.0 license (<https://magrj.mosuljournals.com/>).

INTRODUCTION

Sorghum is one of the grain fodder crops in Iraq, It is also used in some developing countries as food for humans. The yield of Sorghum is limited in Iraq due to many problems that affect the productivity of this crop, as well as the farmers' interest in the yellow corn crop. Therefore, attention must be paid to developing the crop in order to Increasing its productivity per unit area through the use of modern scientific methods that affect the yield, including the appropriate cultivar, mineral fertilization, plant density, planting date, distances and depth of cultivation, irrigation and the type of tillage, And the effect of these factors combined determines the quantity and quality of sorghum yield in addition to its important role in the formation and strengthening of the vegetative and root system of the plant (Chen *et al.*, 2020).

EFFECT OF VARIETIES

Several studies indicated that there are differences between sorghum varieties in height of the plant (PH), No. of leaves, Leaf area (LA) and diameter of the stem. Sorghum cultivars vary in growth traits, plant size, and yield due to their varying response to environmental conditions and and genetic factors. (Prasad *et al.*, 2008). Baktash *et al.*(2009) concluded that the two hybrids Money Maker and High grazer were superior to the sorghum varieties Rabeh and Enqadh and record the highest of

green fodder yield and for the total in two cutting 40.19, 39.15, 37.12 and 37.44 tons/ha and for the spring and autumn seasons, respectively.

Wuhaib *et al.* (2006) found that the cultivar Engadh had the highest plant height, No. of leaves and plant yield in the two study seasons. A number of researchers Al-Bahadli (2006) and Shihab and Jaddoa (2011) indicated that sorghum cultivars did not differ significantly in the grain yield of their plants in both spring and autumn sorghum., However, the cultivar Kavier 2 was insignificantly superior to the two cultivars, Rabeh and Engadh, in grain yield in the autumn season only. Al-Taher *et al.* (2012) observed in his study of fourteen genotypes of sorghum (KAVIER2, MILO, Rabeh, Engadh, Rox, Korakolla, Dorado, GT-1, GT-2, GT-3, NK 6638, Netreed, KS 310), the superiority of Kavier 2 cultivar in plant height, leaf area index and dry matter yield, and the superiority of the Rabeh variety in the weight of a thousand grains, While the superiority of the Enqadh cultivar in number of grains/head and grain of yield it reached 3.4 and 5.1 tons/ha for the seasons 2008 and 2009.

Al-Moussawi *et al.*(2012) found that the cultivar Super grazer record the highest rate in leaf area and its index, dry matter yield and green forage yield were 5697.72 cm², 7.64, 21.20 and 66.92 tons/ha, respectively. Al- Khazali *et al.* (2013) found that the original Lilo cultivar was superior to the improved cultivar in all the traits that were under study, the most important of which is the grain yield. Al-Mozani and Al-Tai (2014) showed that the genotypes significantly affected the yield and quality of forage, as the Sb-0 genotype had the highest rate of the yield of green matter, dry yield and fiber yield amounted to 532.54, 753.61, 169.15, 083.18, 304.8 and 941.9 Ton/ha for the spring and autumn seasons, respectively, While the Sb-9 genotype gave the highest percentage and protein yield of 55.12, 67.12%, 803.1 and 210.2 tons/ha for the two seasons, respectively. Al-Edelbi *et al.* (2015) found that the yield of local cultivars was superior to the yield of green fodder, which amounted to (57.58) tons/ha compared with of green fodder yield for the rest of the cultivars studied. Ahmed and Abboud (2016) showed that no significant increased between Buhouth 70 and Rabeh in some growth traits, where the cultivar Rabeh record the highest grain yield.

In a study conducted by Jabereldar *et al.* (2017) it was found that the genotype Yss-98 recorded the shortest period to reach 50% flowering, which was 79 days, while the genotype Yss-10 recorded the longest period to reach that stage. Abdulla *et al.* (2017) found in a comparative study of two cultivars (Benny and Saif) Of the sorghum that the variety Benny record increased no.of grains/head , 1000 grain weight and grain yield while the cultivar Saif was superior in length of spike in both seasons. Saini *et al.* (2018) did not obtain a significant difference between cultivars GJ 38, GJ 42, SR 2872 and SR 1904 in plant height and grain yield . Tang *et al.* (2018) noted the superiority of cultivar BiomassGN-4 in plant height , stem diameter While no significant differences were observed between two cultivars Sweet GT-3 and BiomassGN-4 in biological yield . Dows *et al.* (2018) found in a study for them the superiority of the two cultivars Supine Dun and Sweet Jumbo in the production of green fodder and gave 60.19 and 60.40 tons / ha, respectively. Al-Faran and Aldoghachi (2019) observed that the Inkath genotype was significantly superior in plant height and 1000-grain weight compared to the Rabeh and Kafier2 genotypes.

Sekou *et al.* (2020) Significant differences between eight cultivars of sorghum and the superiority of two cultivars FADDA and FPHWG in grain yield over the grain yield of the other cultivars studied, grain yield of each cultivar was 4 tons/ha. Tibugari *et al.* (2021) indicated that the variety IS22320 was superior in plant height and Chlorophyll Content Index compared with the cultivar IS9456.

Hussein and Hussein (2021) found when using of three cultivars (Engathe , Rabeh , Kafir) indicated the superiority of the cultivar Engathe in no. of days up to 50 percent flowering and LA while cultivar Rabeh was superiority in no.of branch/plant and no.of leaves/plant . Abood *et al.*(2021) in his experiment in which he used three cultivar (Mabrouk , Buhooth 70 and Giza 113) showed that cultivar Giza113 record significantly superior in plant height , chlorophyll leaves content, dry matter yield, no. of grains/heed , 1000 grain weight and grain yield Compared to the rest of the cultivars. Ahmad *et al.*, (2022) used two varieties (CFSH-30 and SIYONG-3180) in their study and showed that cultivar CFSH-30 was significantly superior in stem weight while cultivar SIYONG-3180 record increase in trait (PH) .

EFFECT OF PLANT DENSITY

The study of Baktash *et al.* (2009) which included four distances for planting between lines, 5, 10, 15 and 20, showed that the highest yield of green fodder was achieved from the use of agricultural distances between the lines of 15 cm in the spring and autumn seasons, which were 40.15 and 34.90 tons / hectare, respectively. Mosavi *et al.* (2009) and Carpici *et al.* (2010) confirmed that the increase in plant densities caused a significant decrease in the stem diameter of plants. Shihab and Jaddoa (2011) found significant differences in grain yield between different plant densities, 27,600, 53,300, 107,600, and 213,300 plants/ha in Grain yield trait, The first density gave the highest grain yield for an individual plant, which amounted to 88.32 and 92.38 g compared to the yield of the fourth density, which reached 37.50 and 42.19 g in the two seasons, respectively. While fourth density significant in grain yield per unit area of 8.00 and 9.00 tons/ha compared to 2.44 and 2.53 tons/ha with the first density and this is due to the fourth density having the highest number of plants / ha.

The study of Al-Khazali *et al.* (2013) found significant differences between three plant densities: 71.4, 95.2 and 143.0 thousand plants/ha. In the study of Aliwi *et al.* (2015) to compare two plant densities of 53 and 98 plants/ha, the results showed that the dry forage yield for the plant density of 98 plants/ha was higher and gave 4.0 tons/ha. Salem (2015) noticed significant increase in plant height , head length , grain yield , straw yield , biological yield and protein percentage when plant density (14000 plant / h a) while plant density (7000 plant/ ha) significant increase in head weight/ plant , grains weight/ head and 1000 grain weight. Ahmed and Abboud (2016) found the superiority of plants planted at space 10 cm between the plants and 50 cm between the lines in height of plant, LA, yield of biological and yield of grain on plants planted with wide distances 20 cm between the unfairness and 70 cm between the lines. Tang *et al.* (2018) noticed when using five plant densities (6, 7.5, 9, 10.5, 12) plant /m² a significant increase in no.of branch/plant at harvest when plant density 6 plant/m² and leaf area index when plant density 12 plant/m². The study of Sekou *et al.* (2020) found the superiority of the yield of grins plant density 53333 plants/ha over the yield of grain plant density 26666 plants/ha. Dembele *et al.* (2021) found that the plant density 53300 plant /ha was better in the plant height , chlorophyll

leaves content, leaf area index, no. of spike/ m², 1000 grain weight and grain yield compared with plant density 26600 plant / ha . Hussein and Hussein (2021) found when using of three plant density (53333 , 71420 , 83333) plant / ha indicated the superiority of the plant density 53333 plant /ha in leaf area and no.of leaves/plant .

EFFECT OF PLANTING DATE

The researcher attributed this decrease to the fact that the environmental conditions were not appropriate, especially the temperature Illumination duration and intensity, which directly affect growth rates. Hadaf and Lufta(2013) found in there study that included four planting dates (1/7, 10/7, 20/7 and 30/7). The planting dates significantly affected plant height, stem diameter, leaf area, and the number of days up to 50% flowering, head length (cm), average weight of one thousand grains (gram), yield per plant (gram) and total grain yield (ton/ha) in both locations. Hussein and Jassim (2015) found that the yield of dry fodder on the spring date of March 30 is superior to the yield of dry forage for the dates March 16, April 13 and 27. Azraq *et al.* (2015) found significant differences in growth characteristics and yield between three planting dates on July 1, 15 and August 10.

Kharbit and Jassim (2015) found that the date planted on March 30 was significantly superior to the dates planted on March (16, 30) and April (13 , 27) in the matter Dry yield (12.25, 9.57 and 5.37) tons. Bughdady (2016) when studying three planting dates (1/7, 15/7 and 1/8) indicated a significant superiority of the planting date 1/7 in plant height, head weight, head grain weight, grain yield, straw yield, biological yield and protein content in grains..Almodares *et al.* (2016) confirmed in a study conducted in Isfahan in the autumn season to test the effect of four dates for planting sorghum, July 5, 14, 25 and August 4, that the height of plant was significantly superior in first date (5 July), and the lowest plant height was recorded on the last date (4 August).

Hadebe *et al.* (2017) noticed significant differences between the sowing dates used in his study, as he noticed the superiority of the early sowing date in the weight of 1000 grains.. Yasen and Abd (2017) confirmed that the third date (1/4) achieved the least no. of days up to 75percent flowering (71 days) and the high no. of days from flowering 75% to physiological maturity (31.22 days) and that the plants planted on the fourth date (11/4). Significantly superior to the highest results for the characteristics of plant height 144.58 (cm) and number of leaves/plant (9.18 leaves/plant), While the second date (20/3) gave the highest results for leaf area characteristics, which amounted to (5491.67 cm²), and the plants grown in the first date excelled (10/3) with the highest stem diameter (2.34 cm). Dera and Mativararira (2018) mentioned in his study of three sowing dates (6 / 12, 20 /12 and 3 /1) that the plants planted on 6/12 recorded the highest values in plant height and grain yield, while the plants planted in 20 /12 achieved the highest value in straw yield.

Asal (2019) used three sowing dates (20 March, 5 April and 20 April) in their study noted the planting date of 5 April record a high in height of plant (181.9 cm),yield of green matter (42.8 ton.he-1), dry matter (11.8 ton.he-1) , protein yield (1.5 ton. he -1), fiber yield (5.9 ton. he-1), protein percentage (12.38 %).

EFFECT OF NITROGEN FERTILIZATION

Nitrogen fertilizer plays a major role in increasing the yield of green and dry fodder for sorghum. The study of Sadoun and Al-Daheri (2011) showed that level 300 kg N/ha was superior with total dry matter yield (28.39 kg.) over the yield of the levels 0, 100 and 200 kg N/ha. Zand and Shakiba (2013) found that increase of

nitrogen fertilizer from 40 to 80 and 120 kg N/ha led to increase in no. of days up 50% flowering and grain yield while the result was not significant between nitrogen fertilizer in no. of tillers/ plant , no. of tillers/m² and stem diameter . Azraq *et al.* (2015) found significant differences between four levels of nitrogen fertilization zero, 45, 90 and 135 kg N/ha, And noticed that Sorghum yield varies with different levels of nitrogen fertilization. In the study of Sibhatu and Belete (2015), the maximum yield of sorghum was reached in the Interface system among cereals and legumes with the addition of 41 kg N/ha in the dry environment. Salem (2015) noticed significant increase in plant height , head length . head length/plant , grans weight/ head and protein percentage when nitrogen fertilizer (100 kg N/ha) compared nitrogen fertilizer (60 and 80 kg N/ ha.

Sher *et al.* (2016) using the recommended amount of nitrogen because an increase or decrease in nitrogen fertilizer negatively affects the quantity and quality of sorghum yield of forage and grain. the study of Shamme *et al.*(2016) proved that the highest grain yield of sorghum was obtained by adding 92 kg of nitrogen/ha. The study of Jung *et al.* (2016) showed there was a gradual increase in the yield of dry forage with increasing levels of nitrogen fertilization from 0, 150, 200 250 to 300 kg N / ha reach its maximum at the level of 300 kg N / ha amounted to 21.7 kg / ton, and the lowest dry forage yield when the control treatment was 10.0 tons / ha .

Al-Dulaimi *et al.* (2017) observed that the nitrogen fertilizer level is 4.5 g/L caused significant increase in grain yield compared to the levels of 1.5 and 3 g/L for the spring and autumn cultivation. Barik *et al.*,(2017) found a significant superiority of nitrogen fertilizer level (100 kgN/ha) in plant height, grain biomass, sugar percentage and sugar yield compared with (0 and 50 kg N/ha). Abdulla *et al.*(2017) explain that increase in length spike, no.of grains./ head , 1000 grain weight and grain yield when increase N fertilizer from 0 to 55, 110 and 165 kg N/ha . Jiyad and Salih (2018) found a gradual increase in the grain yield of sorghum by increasing the levels of nitrogen fertilization from 150 to 300 and then to 450 kg of nitrogen/ha and reaching the highest yield at the level of 450 kg of nitrogen/ha of 6.71 tons/ha. Sahu *et al.* (2018)confirmed that the fertilizer N 120 kg / ha achieved the highest value in head length, No. of grain heads, weight of 1000 grains and plant yield compared to fertilizer N (0, 40 and 80 kg / ha).

Akinseye *et al.* (2020) note when using six tretment of nitrogen (zero, 20 , 40, 60 ,80 and 100 Kg N/ ha), that the level (100 kg N/ ha) was better in the characters of grain yield and biological yield . The study of Sekou *et al.* (2020) found that the level of 81 kg / ha of nitrogen was superior to the level of 41 kg N / ha and the control treatment with a grain yield of 3935 tons / ha . The study of Moi (2021) confirmed that adding nitrogen to the soil led to an increase in grain yield 265 compared with no addition, by adding two levels of nitrogen fertilizer 80 and 40 kg nitrogen / ha. Dembele *et al.* (2021) show that the level (178 kg N/ ha) was better in the characters PH , chlorophyll leaves content, LAI, no. of spike/ m² , , 1000 grain weight and grain yield compare with (zero, 89 Kg N/ha) . Ahmad *et al.* (2022) got on increase in PH and weight of stem in an increase added N fertilizer from control to 150 and 300 kg N.ha⁻¹.

تأثير بعض العمليات الزراعية في نمو وحاصل الذرة البيضاء (*Sorghum bicolor* L.)
(مقال مراجعة)

ريان فاضل احمد العبادي¹ سالم عبدالله يونس غزال² وليد خالد شحاذة الجحيشي³
(1) (2) (3) قسم المحاصيل الحقلية ، كلية الزراعة والغابات ، جامعة الموصل ، العراق

الخلاصة

تعد الذرة البيضاء احد محاصيل الحبوب المهمة وتعود أهميتها إلى استخداماتها المتعددة ، اذ تستخدم كغذاء للإنسان وأعلاف للحيوانات على شكل حبوب مركزة أو علف أخضر ، فضلا عن دخولها في العديد من الصناعات كصناعة النشا والسليلوز والكحول والمكانس والسلال والعديد من المشغولات اليدوية وغيرها. تعتبر الذرة البيضاء أكثر المحاصيل الحقلية الصيفية تحملا للجفاف ، إلا أنها من المحاصيل المجهدة للتربة نتيجة استنزافها العديد من المغذيات وخاصة عنصر النيتروجين. لذلك فإن التسميد ضروري وخاصة بالنيتروجين مما ينعكس في تحسين جودة العلف وزيادة حاصل المادة الجافة. يتأثر نمو وحاصل الذرة البيضاء بالعديد من العوامل البيئية و الوراثة والزراعية والتي يكون في ها النمو والحاصل محصلة تأثير هذه العوامل مجتمعة ، أن اتباع الأساليب الحديثة في خدمة هذا المحصول يعد من العوامل الرئيسية في تحسين إنتاجية الحاصل ومن أهم هذه العوامل هي تحديد الصنف الأفضل و موعد الزراعة الأمثل والكثافة النباتية الموصى بها ومعدل التسميد المناسب الذي يعطي افضل حاصل واقل كلفة وضرر. الكلمات المفتاحية : مواعيد الزراعة ، الكثافة النباتية ، الأصناف

REFERENCES

- Abdulla, A., Muflahi, M. & Basuaid, A. S. (2017).Effect of nitrogen fertilizer and its application efficiency on two local sorghum cultivars *Sorghum bicolor* L. Moench. *Journal of Agricultural Science*,. 9(4) : 236-241. <https://doi.org/10.5539/jas.v9n4p236>
- Abood ,N. M. , Shalal ,E. M. & Hamdan, M. I. (2021). Impact of plant growth inhibitors on the growth and yield of sorghum. *Iraqi Journal of Agricultural Sciences*,52(6):1431-1440. <https://doi.org/10.36103/ijas.v52i6.1484>
- Ahmad ,I, Zhu G , Zhou ,G, Song ,X, Ibrahim, M.E.H. & Salih ,E. G. I. (2022).Effect of N on growth, antioxidant capacity, and chlorophyll content of sorghum. *Agronomy* , 12 : 1-11. <https://www.mdpi.com/2073-4395/12/2/501#>
- Ahmed, Y. A. & Abood ,N. M. (2016). Response of two varieties of sorghum (*Sorghum bicolor* L. Moench) to plant density. *Anbar Journal of Agricultural Sciences*, 41(2):188-203. <https://iasj.net/iasj/download/dda3b619b459435a>
- Akinseye ,F. M., Ajegbe, H. A., Kamara ,A. Y., Adefisan E. A. & Whitbread A. M. (2020) . Understanding the response of sorghum cultivarsto nitrogen applications in the semi-arid Nigeriausing the agricultural production systems simulator . *Journal of Plant Nutrition*,27 :1-17. <https://doi.org/10.1080/01904167.2020.1711943>

- Al-Bahadli, A. AH. J. (2006). *Effect of Weed Competition on Growth Characters and Yield of Some Sorghum Cultivars (Sorghum bicolor L.) Moench*. M.Sc. thesis. College of Agriculture - University of Baghdad. <https://iqdr.iq/search?view=3230f646ffc7a52bf621d57e412db09e>
- Al-Dulaimi, N. M. A., Khreibet ,H. K. & Saleh ,A. K. (2017). Effect of foliar application of nitrogen on grain yield and it's component in sorghum. *Iraqi Journal of Agricultural Sciences*, 48(3): 740-748. <https://cutt.us/3lcTp>
- Al-Edelbi ,R., Sabouh, M.& Al Lahham, G. (2015) Evaluation of some productivity and quality traits of some sorghum[*Sorghum bicolor L. Moench*] genotypes under water stress conditions during grain filling stage. *The Jordanian Journal of Agricultural Sciences*,11(2): 871-882. <https://journals.ju.edu.jo /JJAS/article/view/10325>
- Al- Faran ,J.S.S.& Aldoghachi , K.A.(2019). Response of Sorghum (*Sorghum bicolor L. Moench*) Genotypes to Different Levels of Agricultural Sulfur. *Basrah Journal of Agricultural Sciences*, 32(Spec. Issue 2): 15-24. <https://doi.org/10.37077/25200860.2019.253>
- Aliwi, A. M. ; M. M. Al-Sahoki & L. I. Muhammad (2015). Performance of selected sorghum genotypes in a saline sodic soil. *Iraqi Journal of Agricultural Sciences*, 46(4): 512-522.<https://www.iasj.net/iasj/download/5e6bd0b871437760>
- Al-Khazali, H. AR., Al-Sahoki ,M. M. & Bektash, F. Y. (2013) Genetic variation of some traits of sorghum under population densities : 2-yield and yield components. *Iraqi Journal of Agricultural Sciences*, 44(4): 447-454. <https://www.iasj.net/iasj/article/79978>
- Al-Moussawi, K. Y. M., Saudi,A.H. & Neama,M.J. (2012). Effects of sowing dates on some of growth trails and green forage yield of three sorghum [*Sorghum bicolor L. (moench)*] cultivars.*Journal of Dhi Qar University for Agricultural Research*, 1(1) 23-36. <https://cutt.us/drwzZ>
- Almodares, A., Hassan ,S. & Hoseini, S. (2016). Effect of sowing dates and nitrogen levels for ethanol production from sweet sorghum stalks and grains. *Afric. Journal of Agricultural . Research*. 11(4): 266-275. <http://dx.doi.org/10.5897/AJAR2015.9765>
- Al-Mozani ,S. J. G. & Al-Tai ,K. I. H. (2014). Effect of genotype and cutting stage on yield and forage quality of sorghum crop. *Iraqi Journal of Agricultural Sciences*, 45(6): 537-546. <https://www.iasj.net/iasj/download/86874712546249a1>
- Al-Taher, F. M. M., Al-Rifai,S.I.M. & Al-Zarkani.M.S. (2012). Response of sorghum *Sorghum bicolor L. Moench* genotypesfor different locations and seasons agricultural. *Dhi Qar University Journal*, 8(1): 1-14. <https://cutt.us/SGO1k>
- Asal, S.T. (2019). Effect of cutting stages and sowing dates on forage yield and quality of sorghum (*Sorghum bicolor L.*) . *Tikrit Journal for Agricultural Sciences* , 19 (2):93-99. <https://www.iasj.net/iasj/download/3741ccb9726f135d>
- Azraq, A. A., Daqash.Y.M.I. & Yaqub,S.U. (2015). Effect of sowing date and nitrogen fertilizer rate on yield of sorghum (*Sorghum bicolor L.*) and nitrogen use efficiency. *Journal of Science and Technology*, 16(1):118-128. <http://repository.sustech.edu/handle/123456789/16949>

- Baktash, F. Y., Kazem, M. H. & Al-Naqeep, M. AR. S. (2009). Introduction hybrid sorghum to Iraq. *Iraqi Journal of Agricultural Sciences*, 40(30): 27-36. <https://www.iasj.net/iasj/download/e5a931d11ecb1bdc>
- Barik ,S., Roy ,P & Basu ,S. (2017). Effect of Fertilizer Nitrogen & Potassium on Difference Cultivars of Sweet Sorghum (*Sorghum bicolor* L. Moench) in North-24-Parganas, West Bengal . *International Journal of Applied Agricultural Research*, (12) 2: 199-210. [https://www. Ripublication.com/ijaar17/ijaarv12n2_09.pdf](https://www.Ripublication.com/ijaar17/ijaarv12n2_09.pdf)
- Bughdady, A.M.M.(2016). Response of some sorghum (*Sorghum bicolor* L.) cultivars to sowing dates and phosphorus fertilization under New Valley conditions. *Middle East Journal of Applied Sciences* , 6(4): 1150-1159. <https://www.curreweb.com/mejas/mejas/2016/1150-1159.pdf>
- Carpici, E., Celik, B. N. & Bayram ,G. (2010). Yield and quality of forage maize as influenced by plant density and nitrogen rate. *Turk Journal of Filed Crops*. 15(2): 128-132. <https://www.field-crops.org/assets/pdf/product5131f40617154.pdf>
- Chen ,X.,Wu ,Q., Gao ,Y., Zhang ,J., Wang ,Y. , Zhang R. , Zhou, Y., Xiao ,M. , Xu ,W. & Huang ,R (2020).The role of deep roots in sorghum yield production under drought conditions. *Agronomy*, 10(611):1-15. <http://dx.doi.org /10.3390/agronomy10040611>
- Dembele ,J. S. B , Gano B. , Kouressy, M.,Lamine ,L., Mohamed ,D., Komla ,D., Ganyo K., Sanogo ,S. , Togola ,A., Traore ,K., Vaksman, M.,Teme ,N., Diouf ,D.& Audebert ,A.(2021). Plant density and nitrogen fertilization optimization on sorghumgrain yield in Mali. *Agronomy Journal*, 113:4705–4720. <https://doi.org/10.1002/agj2.20850>
- Dera, J.& Mativavarira, M.(2018). Effect of sowing date and variety on Sorghum yield in deferent Regions of Zimbabwe. *Journal of Advancements in Plant Science*, 1(2):1-6. https://www.researchgate.net/publication /327393800_Effect_of_Sowing_Date_And_Variety_on_Sorghum_Yield_in_Different_Regions_of_Zimbabwe
- Dows ,M., AL-Mowlem ,A.& Basha ,R.(2018). Screening Sorghum Varieties Under Different Climatic Conditions in the Central Highlands of Yemen *Syrian Journal of Agricultural Research* 5(2): 128 - 138. <http://agri-research-journal.net/sjar/wp-content/uploads/2018/07/v5n2p12.pdf>
- Hadaf, Q. M. & Lafta, L. R. (2013). Effect of planting dates and levels of moisture tension on some characteristics of vegetative growth and yield of sorghum, *Sorghum bicolor* L. *Journal of Dhi Qar University*, 8(2): 18-35. <https://cutt.us/DP5qm>
- Hadebe, S.T., Mabhaudhi ,T. & Modi ,A. T. (2017). Water use of sorghum (*Sorghum bicolor* L. Moench) in response to varying planting dates evaluated under rainfed conditions. *Water SA* , 43(1) : 91-103. <http://dx.doi.org/10.4314/wsa.v43i1.12>
- Hussein, A. H. & Jassim ,A. M. (2015). Effect of sowing dates and cutting stages on forage yield and quality of sorghum (var. Abu-Sabeen) : 1-growth traits and green forage yield.*Iraqi Journal of Agricultural Sciences*, 46(4): 475-483. <https://www.iasj.net/iasj/article/105614>
- Hussein , S. Q. & Hussein,A. K. (2021).Effect of plant densities on some growth traits of varieties of Sorghum (*Sorghum bicolor* (L) moench). *Annals of the Romanian*

- Society for Cell Biology*,25(3) : 4455 - 4463. <https://www.annalsofrscb.ro/index.php/journal/article/view/1941>
- Jabereldar, A. A., EL Naim ,A. M., Abdalla, A.A. & Dagash Y.M. (2017). Effect of water stress on yield and water use efficiency of sorghum (*Sorghum bicolor* L. Moench) in semi- arid environment. *International Journal of Agriculture and Forestry*, 7(1): 1-6. <http://dx.doi.org/10.5923/j.ijaf.20170701.01>
- Jiyad, S. H & Salih ,A. M. (2018). Grain yield and seed quality of sorghum ratoons under nitrogen fertilizer. *Engineering and Technology Journal*,63(6):247-252. <https://cutt.us/T9uDO>
- Jung J.S., Kim,Y.J., Kim, W.H., Lee ,S.H., Park ,H.S & Choi K.C. (2016) . Effect of nitrogen fertilization levels and its split application of nitrogen on growth characters and productivity in sorghum× sudangrass hybrids [*Sorghum bicolor* (L.) Moench]. *Korean Society of Grassland and Forage Science*, 36(3):215–22. <http://dx.doi.org/10.5333/KGFS.2016.36.3.215>
- Kharbit, H. K. & Jassim ,A. M. (2015). Effect of sowing dates and cutting stages on forage yield and quality of sorghum (var.Abu- Sabeen) : 2-dry matter and forage quality. *Iraqi Journal of Agricultural Sciences*, 46(4): 484-493. <https://www.iasj.net/iasj?func=article&aId=105615>
- Moi, P. E (2021). *Effect of Intercropping Sorghum with Cowpea and Nitrogen Application on Growth and Yield of sorghum (sorghum bicolor L.) moench*. M.Sc.. Faculty Agriculture - University of Nairobi. <https://cutt.us/kdxvO>.
- Mosavi, S.G.R., Seghatoleslamia, M. J., Java dib ,H. & Niab E.A. (2009). Effect of plant density and planting pattern on yield, yield components and morphological traits of forage sorghum in second cultivation. *Plant Ecophysiology*, 2: 81-84. <https://cutt.us/zlFrJ>
- Prasad, P. V., Ristic ,Z. & Staggenborg ,S. A. (2008). Impact of drought and heat stress on physiological development, growth and yield processes of crop plants. *Advances in Agricultural Systems Modeling Series*,1: 301-355. <https://cutt.us/bwW2K>
- Sadoun, S. N. A. & Al-Daheri ,AA. M. S. (2011). Response of sorghum to nitrogen fertilizer. *Iraqi Journal of Agricultural Sciences*, 42(4) : 17-32. <https://www.iasj.net/iasj/download/210f62345663e2ca>
- Sahu ,H., Tomar ,G.S. & Nandeha N. (2018). Effect of planting density and levels of nitrogen on yield and yield attributes of sweet Sorghum (*Sorghum bicolor* [L.] Moench) Varieties. *International Journal of Chemical Studies*, 6(1): 2098-2101. <https://cutt.us/1Z1pk>
- Saini ,L.H., Trivedi,S.J., Davda ,B.K. & Saini, A.K.(2018). Effect of sowing dates on growth, yield and economics of sorghum (*Sorghum bicolor* L.Moench) genotypes. *Journal of Pharmacognosy and Phytochemistry* , 7(5): 535-538. <https://cutt.us/vGGD7>
- Salem, E. M.M. (2015). Response of grain sorghum (*Sorghum bicolor*, L. monech) to irrigation,nitrogen and plant density under newvalley conditions, Egypt. *Egyptian Journal of Desert Research*, 65(1) :11-30. <http://dx.doi.org/10.21608/ejdr.2015.5775>
- Sekou ,J. , Dembele ,B. , Gano ,B., Vaksman, M. , Kouressy ,M. , Dembele ,L., Doumbia M. , Teme ,N., Diouf, D. & Audebert ,A. (2020). Response of eight sorghum varieties to plant density and nitrogen fertilization in the Sudano-

- Sahelian zone in Mali. *African Journal of Agricultural Research*, 16(10), 1401-1410. <https://doi.org/10.5897/AJAR2020.15025>
- Shamme ,S. K., Raghavaiah ,C. V., Balemi ,T. & Hamza ,I. (2016). Sorghum (*Sorghum bicolor* L.) growth, productivity, nitrogen removal, n- use efficiencies and economics in relation to genotypes and nitrogen nutrition in kellem- wollega zone of Ethiopia, East Africa . *Advances in Crop Science and Technology*, 4(3), 1-8. <https://doi: 10.4172/2329-8863.1000218>
- Sher, A., Ansar ,M., Ijaz, M. & Sattar ,A. (2016). Proximate analysis of forage sorghum cultivars with different doses of nitrogen and seed rate. *Turkish Journal of Field Crops* 21(2):276-285. <https://doi.org/10.17557/tjfc.60032>
- Shihab, H. A. L. & Jaddoa , K. A. (2011). Tillering of grain sorghum as effected by cultivar and plant population density. *Iraqi Journal of Agricultural Sciences*, 42(6): 1-11. <https://www.iasj.net/iasj/article/310>
- Sibhatu, B. & Belete ,K. (2015). Effect of cowpea density and nitrogen fertilizer on a sorghum-cowpea intercropping system in Kobo, northern Ethiopia. *International Journal of Agriculture and Forestry*, 5(6): 305–317. <https://cutt.us/1P6yn>
- Tang ,C.,Sun ,C.,Du ,F. ,Chen ,F. ,Ameen, A. ,Fu ,T. & Xie G. H. (2018). Effect of plant density on sweet and biomass sorghum production on semiarid marginal land. *Sugar Tech (May-June)*, 20(3):312–322. <https://doi.org/10.1007/s12355-017-0553-3>
- Tibugari,H. , Chiduzo,C. , Mashingaidze, A. B. & Mabasa ,S. (2021). Incorporated Sorghum Residues Reduce Emergence and Seedling Growth of Some Crops. *International Journal of Agriculture and Natural Resources* , 48(2):97-107. <https://doi 10.7764/ijanr.v48i2.2298>
- Wuhaib, K. M., Karim ,H. M. & Mahdi, A. M. (2006). Effect of leaves removal at anthesis grain yield and green forage of sorghum. *Iraqi Journal of Agricultural Sciences*, 37(3): 119-126. <https://www.iasj.net/iasj/ download/ 595a28c7505d3205>
- Yasen ,L. I.& Abed ,N. Y. (2017). Effects of planting dates on yield and its components of two sorghum . *Al-Furat Journal of Agricultural Sciences / Supplement Issue* 4: 1273-1247. <https://www.iasj.net/iasj/download/f96f61c9b67a8f66>
- Zand ,N. & Shakiba ,M. R. (2013).Effect of plant density and nitrogen fertilizer on some attribute of grain sorghum(*sorghum bicolor* (l.) moench). *International journal of Advanced Biological and Biomedical Research*, 12 (1): 1577-1582. <https://cutt.us/3cMoG>