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# Irrigation Intervals and Nitrogen Fertilizer on Yield and Water Use Effeciency of Sorghum Fodder

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**Abstract:** ***Two field experiments were conducted in the National Research Centre Experimental Farm at Shalakan, Kaliubia Governorate, Egypt, during 2000 and 2001 summer seasons to study the effect of different rates of nitrogen fertilizer (0,20,40,60 and 80 kg N/fed.) under different irrigation intervals ( 7, 10,13 and 16 days) on yield of sorghum for fodder. The highest fresh matter yield (FMY) and dry matter yield (DMY) in the 1st season were by 7 days irrigation interval. No significant differences in FMY in the 1st and 2nd cut in the 2nd season. DMY of the 1st cut and the DMY in the two cuts were by 16 days between irrigation. Nitrogen fertilization caused pronounced increases in FYM and DYM of the 1st and 2nd cuts. Generally, the highest effect of N fertilizer was obtained with the highest doses used i.e. 60 and 80 kg /fed under all irrigation intervals in both seasons. Irrigation affected significantly the FMY in the 1st as well as 2nd seasons; however, the differences in the 2nd season were not significant. In 2000 season, the highest FMY were by 7 days irrigation interval FMY increased as nitrogen fertilizer increased up to the highest level used. Addition of 80 kg N/fed led to increases in FMY reached to 21.16, 26.90 and 25.11 %, for 1st, 2nd and the two cuts, in the 1st season, and the increases amounted by: 61.16,28.30 and 44.81 % in the 1st, 2nd and the two cuts, in the 2nd season, respectively, compare to that without mineral fertilizer. In the 1st season, the highest increments were by addition of 80 kg N/ fed and 7 days irrigation intervals. These were true for the 1st or 2nd cut and total yield of the two cuts. The lowest increment with the same dose of N was by irrigation every 16 days. In the 2nd season, different figures were obtained, in the 1st cut, the highest increases were by 80 kg N and 13 days intervals followed by that under 10 days within irrigations, however, the lowest were by 16 days frequencies. In the 2nd cut, addition of the highest rate of nitrogen gave the highest positive effect on fresh yield under 7 days intervals, where the lowest effect were under 10 days intervals. The total FMY gave its higher values and increments by irrigation every 13 days and applied 80 kg N/fed. Furthermore, the differences in increment caused by the doses of N fertilizer were approximately equal when plants irrigated every 7 or 16 days in the 2nd cut and the yield of two cuts were in the 1st season by plants irrigated every 10 days. Water use efficiency increased by the widening of irrigation intervals and N fertilization increased its values under the all irrigation intervals.***

**Keywords**: Sorghum-Irrigation intervals-Nitrogen fertilizer-Fresh matter-Yield (FMY)-Dry matter yield (DMY)-Water use Efficiency, Insect infestation.

## 1. Introduction

Shortage of green forages in summer is one of the important problem face farmers and livestock breeders. Great difficult for increase the area according to the high competition in the cropping system in the Nile Valley as well as Delta. Therefore, many efforts directed to increase the area, quantity and quality of forage crops in the new reclaimed areas. Lack of water, salinity and low fertility are the main challenges against these goals. In old lands the competition are the main problem, therefore, different programs were conducted to raise the productivity of forage crops per unite area by cultivated high yield new species and varieties specially those lesser in water requirement. In addition, increased the area of forage crops in the new reclaimed lands by crops tolerates drought and salinity. Improving cultural practices also considered an important way to increase the productivity in old and new areas to face the gape in white and red meat. Water stress and its effect on yield of sorghum were studied by many authors:[1] concluded that wide irrigation intervals with saline water caused growth and yield depressions of plants as a result of both drought and salinity conditions. [2] reported little significant decrease in fresh and dry weight and protein yield with increasing irrigation intervals from 5-10 days on alfalfa plants. **[3], [4]** on sorghum, observed that prolonging irrigation intervals from 5-10 days caused a depression in growth and yield of forage. However, **[5]** found that the narrow irrigation recorded insignificant increases in growth and forage yield except number of tiller/unite area in both cuts in the 1st season and plant height in the 1st cut in the 2nd season. Sorgum infested with may insect pest especially *Rhopalosiphum padi & R. maidis*, **[6] ,[7],**[8], [9] . Many reported have been related to WUE and production and clearly explained the linear relationship between WUE and production in wheat, maize and other crops [10] **and [11]**. Numerous studies recorded the improving effect of nitrogenous fertilizers in yield of forage crops:[12] **and [13][14]. [15] and [5]** detected an increase in the yield on two forage crops as the increase in N sources but ammonium nitrate more effective than ammonium sulfate or urea in the rate of 60 kg/fed. [14] reported that application of fertilizer resulted in an increase in accumulated of biomass during the 1st stage of growth with this effect becoming more significant at later growth stages. The highest yields were recorded by 80 kg N/ha [16] .

The positive relations between nitrogenous fertilization and WUE were shown in crops by: **[17] , [18] and [19]**. This work was designed to study the effect of different nitrogen fertilizer rates under different irrigation intervals on yield of fodder sorghum crop.

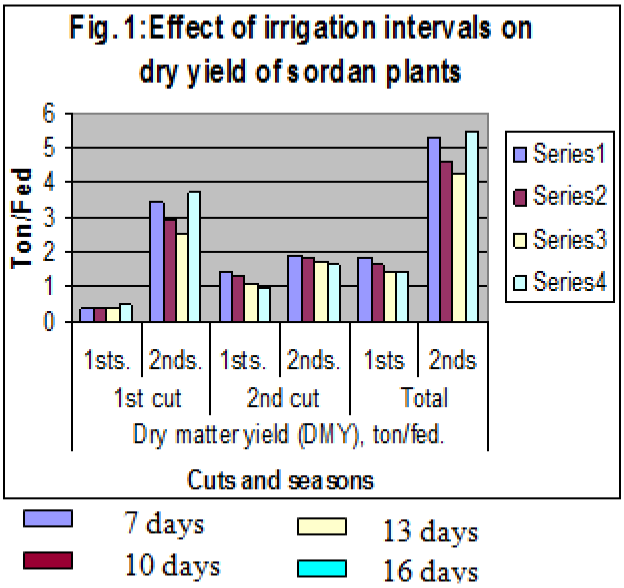
## 2. Material and Methods

Tow field experiments were conducted in the Experimental Farm of the National Research Center at Shalakan, Kaluobia Governorate during the 2000 and 2001 summer seasons to evaluate the effect of nitrogenous fertilizer under different irrigation intervals on yield of fodder sorghum. The treatments were as follows: Irrigation intervals: 7, 10, 13 and 18 days. - N fertilizer levels: 0, 20, 40, 60 and 80 kg N / fed. Every experiment included 16 treatments in split plot design in 6 replicates which the irrigation treatments laid in the main plots and the nitrogen levels were distributed randomizly in sub plots. Seeds of fodder sorghum named Sordan [as a hybrid between Sweet surgo (*Sorghum bicolor Lhu.*) and Sudan grass (*Sorghum sodanase L.*)] were sown in the 1st of August in both seasons. Calcium supper phosphate (16 % P205) and Potassium sulfate (48.5 % K20) in the rate of 200 and 100 kg / fed were broadcasted before sowing. Ammonium sulfate (20.5 % N) was added as treatments in two equal portions, the 1$^{st}$ one was applied 21 days from sowing and the 2$^{nd}$ was added two weeks latter. Fresh and dry matter yields for two cuts in the two seasons were measured. All collected data were subjected to the proper statistical analysis as the methods described by **[20]**

## 3. Results

### 3.1 Irrigation Intervals

Data illustrated in Table (1) shows that irrigation affected significantly the fresh matter yield (FMY) in the 1$^{st}$ as well as the 2$^{nd}$ season, however the differences in the 2nd season were not significant. In 1999 season, the highest FMY were by 7 days irrigation interval in the 2nd cut and the yield of two cuts were in the 1st season by plants irrigated every 10 days.

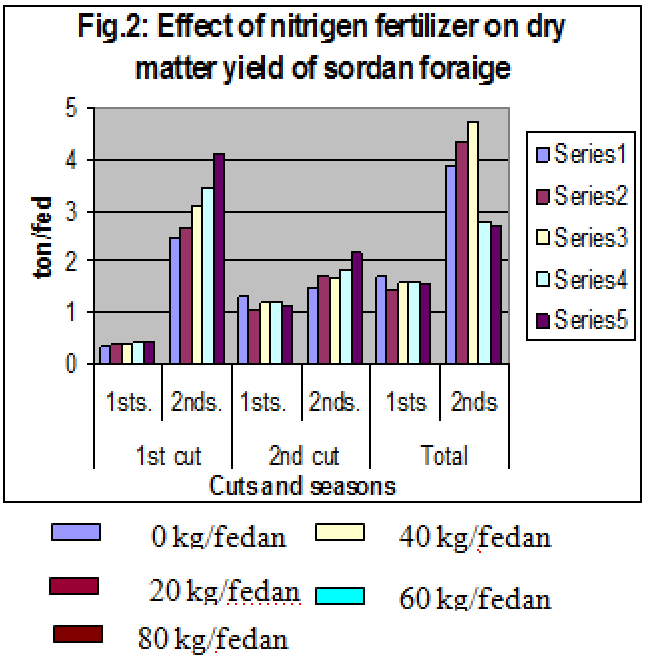



### 3.2 Irrigation intervals

Examination of Data in Table (4) noticed that widening the irrigation intervals led to increase the water use efficiency. Plant heights and leaf area indices of forage sorghum were higher in the frequently watered plots than in plots where irrigation water was delivered less frequently. Averaged over the two seasons, maximum dry matter (DM) yields were 16.3, 11.8, and 10.5 tones ha$^{-1}$ for frequent, intermediate, and infrequent irrigation regimes, respectively. Light, frequent irrigation resulted in a significantly higher water use efficiency (WUE) compared to the other two regimes, thus increasing the return from irrigation. These results suggest that in such semiarid environments, DM yields and WUE of forage sorghum could be increased by combining light irrigation with a short interval.

### 3.3 Nitrogen fertilizer

Data recorded in Table (2) revealed that FMY increased as nitrogen fertilizer increased up to the highest level used. Addition of 80 kg N/fed led to increases in FMY reached to 21.16, 26.90 and 25.11 %,in the 1$^{st}$, 2$^{nd}$ and the two cuts, in the 1st season, and the increases amounted by: 61.71, 28.30 and 44.81% in the 1$^{st}$, 2$^{nd}$ and the two cuts, in the 2nd season, respectively, compare to that without mineral fertilizer. This data are in harmony with those obtained by [21], [22].




The increment in FMY may be related to the increases in plant height, number of green leaves, stem diameter and fresh and dry weight of different plant parts. Such increase in the above mentioned characters as a result of N application explained the rate of N in the internodes elongation and greater capacity of metabolites building due to enlarged plant leaf area at higher N doses during vegetative growth.

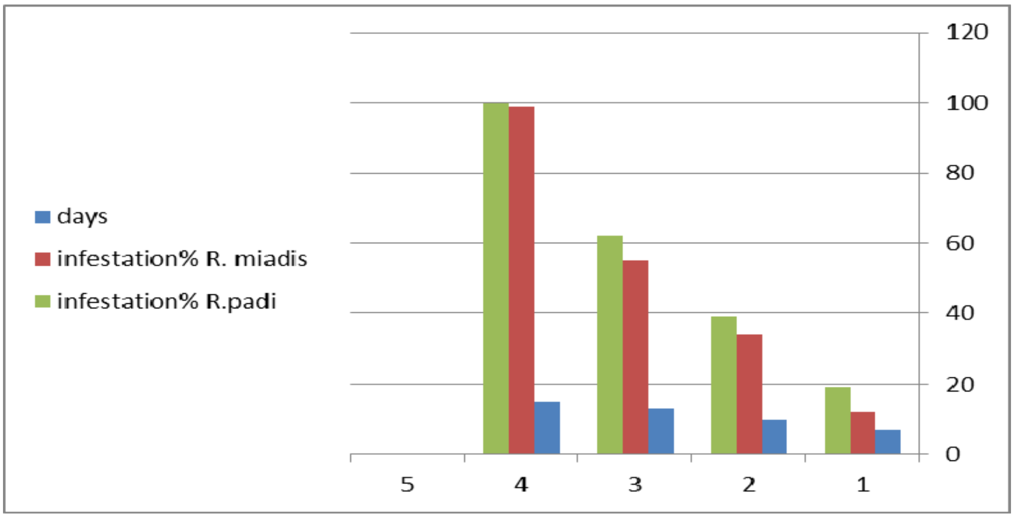



**Figure 3:** Effect of irrigation on pests infestations

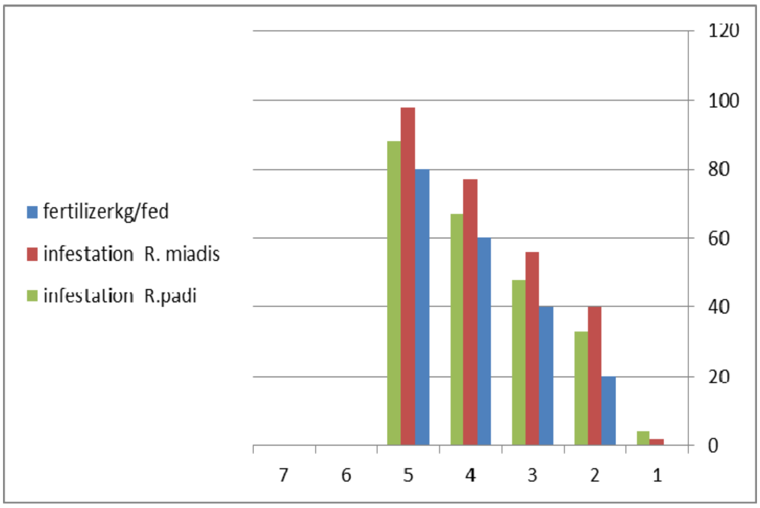



**Figure 4:** Effect of nitrogenous infestations on pests infestations

Figure 3 and 4 show the infestations of the insect pests after the irrigation period which show the infestations increased when the irrigation period increased. 2011,

### 3.4 Interaction

The interaction effect of nitrogen fertilization and irrigation intervals on fresh and dry matter yields were noted in Table (3&4). These data indicated that, in the 1st season, the highest increments wee by addition of 80 kg N/ fed and 7 days irrigation intervals. This was true for the 1st or 2nd cut and total yield of the two cuts. The lowest increment with the same dose of N was by irrigation every 16 days. In the 2nd season, different figures were obtained, in the 1st cut, the highest increases were by 80 kg N and 13 days intervals followed by that under 10 days within irrigations, however, the lowest were by 16 days frequencies. In the 2nd cut, addition of the highest rate of nitrogen gave the highest positive effect on fresh yield under 7 days intervals, where the lowest effect were under 10 days intervals. The total FMY gave its higher values and increments by irrigation every 13 days and applied 80 kg N/fed. Furthermore, the differences in increment caused by the doses of N fertilizer were approximately equal when plants irrigated every 7 or 16 days. Concerning the water use efficiency, Data in Table (4) indicated that the values of WUE higher in the 1st cut in the 2nd season followed by that in 1st cut in the 1st season. However, the lowest values were shown in the 2nd cut in the 1st season followed by that in the 2nd cut of the 2nd season. Increasing nitrogen increased the percentage of increment WUE. For the 1st cut, the highest values were by adding 80 kg/fed N. This was true under the different irrigation intervals in the 1st cut in both seasons. In the 2nd cut of the 2nd season, the response was similar but in the 1st season the response was differ which the highest values was by the 60 kg/fed when the irrigation intervals were applied at 10, 13 and 16 days, respectively. The highest increment was shown by 80kg/fed when plants irrigated every 7 days in the 1st cut of the 2nd seasons. On the other hand, nitrogen fertilizer addition decreased the values of WUE in the 2nd cut in the 1st season with the same irrigation interval.. Data in Table (4) pointed out, generally, that there was a positive relationship between N fertilization and water use efficiency. This was more pronounced in the 2nd cut in the 2nd season.

## 4. Discussion

This data was in line with those obtained by: [21], **[22]**. **[23]** examined the effect of irrigation frequency and show that the yield of maize straw decreased by widening or narrowing the irrigation intervals than 15 days. However, **[4]** found that prolonging of irrigation intervals more than 5 days decreased the fresh yield of sorghum grown in salt affected soil in Ras Sidr in Sinai. Meanwhile**, [24] and [25], [26], [27]** concluded that increasing soil moisture increased growth and yield of crops cultivated for forage or for seeds. Water stress led to cease the cell division and enlargement of different plant tissues which intern depressed the vegetative growth and dry matter accumulation[28] **and [27]**. Furthermore, water excess or water logging led to the decrement of oxygen surrounding the roots and this reflected on the root growth and water as well as mineral absorption (**[29] and [30]).** The regulation of N fertilizers and its effect on growth and yield of forages were reported by [32] **[31] [25]** reported that regression analysis revealed that the response of plant height, dry weight of leaves and stems and total dry weight/plant, stem diameter, number of green leaves, LA/plant and LWR showed a quadratic response to nitrogen fertilization and their characters could be increased by adding N levels up to 120 kg/fed. Moreover, [25] concluded that excess of the nitrogen levels directed the plants to more vigorous growth and intern reflected in fresh and dry matter yields. [17] **and [34]** confirm this finding. In addition, Dawson, *et al*. (2008) concluded that beneficial genetic traits include the ability to maintain photosynthesis and N uptake under N stress and the ability to extract soil N at low concentrations, perhaps through beneficial associations with soil microorganisms. In addition, breeding for specific adaptation to climactic and management practices so that crop uptake patterns match N availability patterns, while minimizing pathways of N loss, will be critical to improving NUE.lso, after nitrogenous fertilization the infestation percent increased due to the plat fertilization. [35], [36] ,[37], [38], [39].[40] [6] find the same obtains. [41] found that irrigation increased yield of brewing barley by 20% and fodder barley by 23%. High NPK rates up to 420 kg/ha increased the yield by 106 and 115 %, respectively. The combined effect of both measures increased the yield of brewing barley by 145% and that of fodder barley by 161%. The increasing of drought resistance by addition of fertilizers was reported by: [42] **[25]. [22] and [43]** Stated that Soil water and nutrients play an important role in increasing sorghum (*Sorghum biclor L. Moench*) yields in the Vertisols of semi-arid tropics during post-rainy season. The highest positive effect on yields was obtained when nitrogen fertilizer added in wetted seasonsThe promoting effect of nitrogenous fertilizers on the WUE was demonstrated by: **[17] and [34]** confirm this finding. Furthermore, **[44]** indicated that an increase in N applications is not a good strategy to compensate for a decrease of total biomass (TB) under drought stress conditions. We concluded that the effect of N fertilizer on TB depends on the availability of water in the soil, and that the amount of N fertilizer applied should be decreased under drought stress con.**[45]** mentioned that the sensitivity was greatest at the early stage ('leaf'), when a temporary soil water stress reduced the biomass production by up to 30% with respect to the control and WUE was 4.8 g $kg^{-1}$ (average of three seasons). These results help quantify the effects of water constraints on sweet sorghum productivity. The water stress in crops led to improve the WUE and AWP in different crops as found by several investigators: [10] **; and [46]**. Furthermore, [47] **, [48], [49]** confirmed the research results led to conclude that moderate drought is successful in increasing water productivity for various crops without causing severe yield reductions. Nevertheless, a certain minimum amount of seasonal moisture must be guaranteed. Moderate drought requires precise knowledge of crop response to drought stress, as drought tolerance varies considerably by genotype and phonological stage. In developing and optimizing moderate drought strategies, field research should therefore be combined with crop water productivity modeling. The effect of regime on water use efficiency was reported by **[50]** on canola and[51] on sorghum. **[52]** mentioned that these irrigation regimes meant heavier water inputs with increasing irrigation frequency.

## References


[1] Hegab, M.A. (1983). Physiological and biochemical responses of sorghum plants and grain yield for fertilization and irrigation regime in Saini. Ph.D. Thesis, Fac. of Agric., Ain Shams Univ., Cairo, Egypt.

[2] Tag El-Din, S.S. and Assaeed, A.M. (1995) Effect of phosphorus fertilization and irrigation frequency on yield and protein content of Alfalfa. J. King Saud Univ., 7(1): 49.

[3] El-Afandy, Kh. T.; Mourad A.F. and Latif, S.J.(1999). Effect of bio-fertilizers and irrigation intervals on growth, yield and yield components of some sorghum cultivars under salinity conditions as Wadi Sidr south Saini. Annals of Agric. Sci. Moshtohor, 37 (4): 2135.

[4] Nassar, Zenab, M.; Nour El-Dien, Nabiela, M. and El-Hussanien, A.A. (2000). Effect of moisture stress and re-sooking with IAA on forage yield of *Sorghum bicolor. L.* grown in salt affected soil at Wadi Sidr. Ann. Agric. Sci., Ain Shams Univ., Cairo, Egypt, 45 (1): 201 - 214.

[5] Abdalla, S.O, Ahmed, K.M. and Schakchouk, F.M. (2004).Comparative studies in two forage grass species under different sources of nitrogen fertilizer and water regime at South Saini, Egypt. J. Agron., 26: 33-48.

[6] Sabbour, M, M. 2006. Effect of some fertilizers mixed with bioinsecticides on the potato tuber moth *Phthorimaea operculella* infesting potato in the field and store. Pak. Of Biol. Sci. (1) 10: 1929-1934.

[7] Sabbour, M.M , 2007. Evaluations of some entomopathogenic fungi and the predator *Coccinella septempunctata* against cereal aphids in Egypt, 2007. Egypt**.** Bull. ent. Soc. Egypt. Econ. 33: 165-174.

[8] Sabbour, M. M. and A. F. Sahab 2007. Efficacy of some microbial control agents against *Agrotis ipsilon* and *Heliothis armigera* in Egypt . Bull. N. R. C. Egypt. 32: 561-571.

[9] Sabbour, M.M and Shadia E-Abd-El-Aziz 2007. Efficiency of Some Bioinsecticides Against Broad Bean Beetle, *Bruchus rufimanus* (Coleoptera: Bruchidae). Res. J. of Agric. and Biol. Sci. 3(2): 67-72.

[10] Gao, S.G.; Wang, W.J. and Guo, T.C. (2004). C-N metabolic characteristics in flag leaf and starch accumulating developments in seed during grain filling stage in two winter wheat cultivars with different spike type. Acta Agron., Sin., 29(3): 427–431.

[11] Hu, Y.C.; Shao, H.B.; Chu, L.Y. and Gang, W. (2006). Relationship between water use efficiency and Production of different wheat genotypes as soil water deficit. Colloids and Surfaces B: Biointerfaces, 53: 271–277.

[12] Sabbour, M.M and Abbass, M.H.2007. Efficacy of some microbial control agents against onion insect pests in Egypt. Egypt. J. boil. Pest. Cont. 17: 23-27.
[13] Sabbour, M. M and Hany, A. 2007a. Controlling of *Bemisia tabaci* by *Verticillium lecanii* and *Paecilomyces fumosoroseus* in potato field. Egypt**.** Bull. ent. Soc. Egypt, 33:135-141
[14] Sabbour, M. M and Hany, A. 2007. Evaluations of some entomopathogenic fungi and *Trichogramma evanescens* on the potato tuber moth in the field Egypt**.** Bull. ent. Soc. Egypt. Egypt**.** Bull. ent. Sco. Egypt, 33: 115-123
[15] Sabbour, M. M and Abdel-Rahman, A . 2007. Evaluations of some terpenes and entomopathogenic fungi on three sugar beet insect pests. J. Boil. Pest. Cont. 17:22-29.
[16] Sharma, R.P.; Dadheech, R.C. and Jat, L.N. (2000). Effect of atrazine and nitrogen on weed growth, yield of sorghum. Indian J. of Weed Sci. 32(1/2): 96- 97.
[17] Sabbour, M, M. 2006. Effect of some fertilizers mixed with bioinsecticides on the potato tuber moth *Phthorimaea operculella* infesting potato in the field and store. Pak. Of Biol. Sci. (1) 10: 1929-1934.
[18] Sabbour.M.M.and M. H. Abbass, 2006. The role of some bioagent mixed with some fertilizers for the control of onion pests. pak. J. Appl. Sci.2(9): 624-628.
[19] Li, Y.; Chen, C. and Wang, J.(2004). Effect of irrigation method and N-fertilizer management on rice yield, water productivity and nutrient-use efficiencies in tipical lowland rice conditions in China. Paddy Water Environ., 2: 195–206.
[20] Sendecor, G.W. and Cochran, W.G.(1990).”Statistical Methods” Iowa State Univ., 8th Ed. Iowa, USA.
[21] Ihtisham, M.L; Haq ; Amanuullah Jan.; Muhammed skafi Juhan Bakht; Jan A. and Shafi M. (2000). Fodder yield of sorghum as influenced by different nitrogen levels and time irrigation. Sarhad J. Agric. 16, 253.
[22] Patel, S.L; Rao, M.S.; Nalatwadmath, S., K. and Reddy, K.K (1999). Response of rabio sorghum to moisture, plant population and nitrogen levels and its residual effect on Bengalgrona growth and yield in the vertisalo plateau of decon plateau. Advances in Agric. Res., India 12, 17.
[23] El-Batanony, K.M.; Hussein, M.M. and Abo El-Khier, M.S. (1988*)*.Response of *Zea mays* to temporal variation of irrigation and salinity under farm condition in the Nile Delta. Intr. Conf. Plant growth drought and salinity in the Arab Region. Dec. 3-7, 1988, Cairo.
[24] Ghaleb, A.A. (2001). Comparison of water use efficiency for major forag crops grown in Yaman. Alex. Sci. Exch., 22(4): 3763- 3788.
[25] Hussein, M.M., Saleh A.L; Abd El-Khader A.A and Abo El-Liell A.A (2002). Irrigation intervals and nitrogen fertilizer and their effects on growth and micronutrients status on fodder sorghum. 18th ICID and 53rd of IEC Congress, August, Montreal, Canada.
[26] Hussein, M.M. (2004). Water stress and its effect on growth of cotton plants **(**Review**)**. Proc. of the Plenary Meeting, Interregional Co-operative Research Network. Thessalonike, Greece.
[27] Hussein, M.M.; Mohamed, S.A. and Taalab, A.S. (2006). Influence of drought and foliar application on nutrients status in shoots of barley plants. Egypt. J. Agron., 28(1): 35–46.
[28] Ashraf, M. (2010). Inducing drought tolerance in plants: Recent advances Biotechnology Advances, Volume 28, Issue 1: 169-183.
[29] Qureshi, R.H. and Barerett-Lennert, E.G. (1998). Saline Agriculture for Irrigated Land in Pakstan. A Handbook, Australian Centre for International Agricultural research, Canberra, Australia,pp. 142.
[30] Saquib, M.; akhtar, J.; and Qureshi, R.H. (2004). Pot study on wheat growth in saline and waterlogged compacted soil. II- Root growth and leaf ionic relations. Soil & Tillage Res., 77: 179–187.
[31] Bleder, F.; Spiertiz, J.H.; Bouman, B.A.; Lu, G. and Tuong, T.P. (2004). Nitrogen economy and water productivity of lowland rice under water-saving irrigation. Field Crop Res., 93(2-3): 169–85.
[32] Marsalis, M.A.; Angadi, S.V. and Contreras-Govea, F.E. (2010). Dry matter yield and nutritive value of corn, forage sorghum, and BMR forage. Field Crops Research, 116, Issues 1-2: 52-57.
[33] Banedjschafie, S.; Bastani,, S.; Widmoser, P. and Mengel, K. (2007). Improvement of water use and N fertilizer efficiency by subsoil irrigation of winter wheat.European Journal of Agronomy, In Press, Corrected Proof, Available online 31 May, 2007.
[34] Sabbour.M.M.and M. H. Abbass, 2006. The role of some bioagent mixed with some fertilizers for the control of onion pests. pak. J. Appl. Sci.2(9): 624-628.
[35] Sabbour, M. M. and A. F. Sahab 2007. Efficacy of some microbial control agents against *Agrotis ipsilon* and *Heliothis armigera* in Egypt . Bull. N. R. C. Egypt. 32: 561-571.
[36] Sabbour, M. M.2007b. Effect of some natural bioagents and natural enemies against aphids in wheat fields J. Boil. Pest. Cont 33: 33-39.
[37] Sahab, A .F and Sabbour, M.M, (2011). Virulence of four entomopathogenic fungi on some cotton pests with especial reference to impact of some pesticides, nutritional and environmental factors on fungal growth. Egyp. J. biol pest cont. 21 (1): 61-67.
[38] Sabbour, M.M., M. Ragei and A. Abd-El Rahman, 2011. Effect of Some Ecological Factors on The Growth of *Beauveria bassiana* and *Paecilomyces fumosoroseus* Against Corn Borers**.** Australian Journal of Basic and Applied Sciences, 5(11): 228-235, 2011.
[39] Sabbour, M.M . (2012). Evaluations of some bioagents against the rice weevil *Sitophilus oryzae* under laboratory and store conditions. *Integrated Protection of Stored Products. IOBC-WPRS Bulletin Vol. 81, pp. 135-142*.
[40] Wojtasik, D. (2004). Effect of irrigation and mineral fertilization on the yield of brewing and fodder cultivars of spring barley. Acta Agronomica, 3(2): 119-129.
[41] Krantze, A. (1997). Yield and grain quality of winter wheat grown under ecological conditions and with intense mineral fertilizer application. Zeszyty Problemowe Postepow Nuak Rdniczych, 439: 201 – 204.
[42] Patel, S.L. and Sheelavantar, M.N. (2006). Soil water conservation and yield of winter sorghum (*Sorghum bicolor* L. Moench) as influenced by tillage, organic materials and nitrogen fertilizer in semi-arid tropical India. Soil and Tillage Res. 9, Issue 2:246-257.
[43] Gheysari, M.; Mirlatifi, S.M.; Bannayan, M.; Homaee,

M. and Hoogenboom, G. (2000). Interaction of water and nitrogen on maize grown for silage Agricultural Water Management, Volume 96, Issue 5, May 2009, Pages 809-821.

[44] Mastrorilli, M.; Katerji , N. and Rana , G. (1999). Productivity and water use efficiency of sweet sorghum as affected by soil water deficit occurring at different vegetative growth stages. European Journal of Agronomy. 11, Issues 3-4: 207-215.

[45] Bluemling, B.; Yang, H. and Wostl, C.P. (2007). Making water productivity operational-A concept of agricultural watyer productivity exemplified at a wheat-maize cropping pattern in the North China Plan. Agric. Water Manag., 91: 11–23.

[46] Dawson, J.C.; Huggins, D.R. and Jones, S.S. (2008). Characterizing nitrogen use efficiency in natural and agricultural ecosystems to improve the performance of cereal crops in low-input and organic agricultural systems. Field Crops Research, 107, Issue 2: 89-101.

[47] Deab, G.M. (1998).Physiological and morphological studies on some sorghum Cultivars growing under saline and sandy soils conditions. Ph.D.Thesis, Fac. of Agric., Cairo Univ., Cairo, Egypt.pp221.

[48] Hussein, M.M. and Aliva, A.K. (2014). Growth, yield and water use efficiency of forage sorghum as affected by NPK fertilizer and deficit irrigation. American J. of Plant Science, 2014, 5:

[49] Mehane, H.M.; Hussein, M.M. and Gafaar, N.A. (2013).Using growth regulators for improving water use efficiency of canola under water deficit. Middle East J. of Appl. Sci., 3(4):161-168.

[50] Saeed, I.A. and El-Nadi, A.H. (1998).Forage sorghum yield and water use efficiency under variable irrigation. Irrigation 18, (2): 81–85.

**Table 1:** Yield of forage sorghum as affected by irrigation intervals

| *Irrigation intervals day* | *Fresh matter yield (FMY), t/fed* | | | | | | *Dry matter yield (DMY), ton/fed.* | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *1st cut* | | *2nd cut* | | *Total* | | *1st cut* | | *2nd cut* | | *Total* | |
| | *1st s* | *2nd s.* | *1st s.* | *2nd s* | *1st s.* | *2nd s.* | *1st s.* | *2nd s.* | *1st s.* | *2nd s.* | *1st s* | *2nd s* |
| 7 | 3.27 | 7.60 | 9.36 | 7.35 | 13.08 | 14.96 | 0.356 | 3.386 | 1.409 | 1.896 | 1.825 | 5.282 |
| 10 | 3.98 | 7.56 | 8.89 | 7.35 | 12.87 | 14.91 | 0.332 | 2.953 | 1.299 | 1.805 | 1.628 | 4.575 |
| 13 | 3.77 | 6.77 | 8.35 | 7.19 | 12.27 | 13.45 | 0.355 | 2.556 | 1.075 | 1.699 | 1.430 | 4.226 |
| 16 | 3.65 | 7.98 | 8.38 | 7.89 | 12.04 | 15.85 | 0.471 | 3.697 | 0.934 | 1.673 | 1.405 | 5.470 |
| LSDat5% | 0.18 | N.S. | 0.075 | N.S | 0.246 | 1.25 | 0.03 | 0.271 | 0.075 | 0.133 | 0.354 | 0.225 |

**Table 2:** Yield of forage sorghum as affected by nitrogen fertilizer

| *Nitrogen fertilizer kg/fed* | *Fresh matter yield (FMY), t/fed* | | | | | | *Dry matter yield (DMY), ton/fed.* | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *1st cut* | | *2nd cut* | | *Total* | | *1st cut* | | *2nd cut* | | *Total* | |
| | *1st s* | *2nd s.* | *1st s.* | *2nd s* | *1st s.* | *2nd s.* | *1st s.* | *2nd s.* | *1st s.* | *2nd s.* | *1st s* | *2nd s* |
| 0 | 3.45 | 5.98 | 7.62 | 6.36 | 11.07 | 17.05 | 0.367 | 2.440 | 1.336 | 1.488 | 1.703 | 3.888 |
| 20 | 3.55 | 6.27 | 8.52 | 7.17 | 12.07 | 13.44 | 0.388 | 2.647 | 1.035 | 1.707 | 1.423 | 4.354 |
| 40 | 3.74 | 7.37 | 8.91 | 7.52 | 12.65 | 14.89 | 0.403 | 3.086 | 1.198 | 1.649 | 1.601 | 4.735 |
| 60 | 3.98 | 8.37 | 9..26 | 7.99 | 13.24 | 16.36 | 0.409 | 3.466 | 1.188 | 1.832 | 1.597 | 2.785 |
| 80 | 4.18 | 9.67 | 9.67 | 8.16 | 13.85 | 17.87 | 0.409 | 4.101 | 1.142 | 2.175 | 1.551 | 2.693 |
| LSD at 5 % | 0.029 | 0.720 | 0.674 | 0.360 | 0.385 | 0.290 | 0.015 | 0.47 | 0.041 | 0.233 | 0.360 | 0.379 |

**Table 3:** Effect of nitrogen fertilizer and irrigation intervals on yield of forage sorghum

| Irrigation intervals Day | Nitrogen fertilizer kg/fed | Fresh matter yield (FMY), t/fed | | | | | | Dry matter yield (DMY), ton/fed. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1st cut | | 2nd cut | | Total | | 1st cut | | 2nd cut | | Total | |
| | | 1st s | 2nd s. | 1st s. | 2nd s | 1st s. | 2nd s. | 1st s. | 2nd s. | 1st s. | 2nd s. | 1st s | 2nd s |
| 7 | 0 | 3.30 | 6.15 | 7.78 | 5.90 | 11.08 | 12.05 | 0.408 | 2.469 | 2.005 | 1.329 | 2.413 | 3.798 |
| | 20 | 3.52 | 7.00 | 8.93 | 7.17 | 12.45 | 14.17 | 0.031 | 2.557 | 1.084 | 1.784 | 1.415 | 4.341 |
| | 40 | 3.74 | 7.56 | 9.48 | 7.27 | 13.22 | 14.83 | 0.396 | 3.381 | 1.314 | 1.671 | 1.710 | 5.052 |
| | 60 | 3.88 | 7.75 | 9.98 | 8.13 | 13.87 | 15.88 | 0.489 | 3.672 | 1.198 | 2.272 | 1.687 | 5.944 |
| | 80 | 4.16 | 9.58 | 10.63 | 8.30 | 14.78 | 17.86 | 0.454 | 4.852 | 1.448 | 2.424 | 1.899 | 7.276 |
| 10 | 0 | 3.63 | 5.92 | 7.93 | 6.37 | 11.56 | 12.29 | 0.399 | 2.47 | 1.281 | 1.558 | 1.626 | 4.028 |
| | 20 | 3.63 | 6.27 | 8.68 | 7.10 | 12.31 | 13.37 | 0.335 | 2.751 | 1.227 | 1.6511 | 1.562 | 4.402 |
| | 40 | 3.87 | 7.03 | 8.95 | 7.43 | 12.82 | 14.46 | 0.319 | 2.679 | 1.326 | 1.695 | 1.645 | 4.274 |
| | 60 | 4.36 | 9.03 | 9.18 | 7.83 | 13.54 | 16.86 | 0.301 | 3.209 | 1.422 | 1.777 | 1.723 | 4.981 |
| | 80 | 4.39 | 9.56 | 9.75 | 8.03 | 14.14 | 17.59 | 0.304 | 3.655 | 1.242 | 2.444 | 1.582 | 6.099 |
| 13 | 0 | 3.44 | 5.22 | 7.33 | 5.97 | 10.77 | 11.19 | 0.198 | 1.563 | 1.145 | 1.316 | 1.341 | 2.857 |
| | 20 | 3.47 | 5.65 | 8.43 | 6.83 | 11.80 | 12.41 | 0.393 | 2.041 | 1.009 | 1.718 | 1.402 | 3.759 |
| | 40 | 3.88 | 6.47 | 8.75 | 7.37 | 12.43 | 13.84 | 0.382 | 2.612 | 1.217 | 1.507 | 1.599 | 4.119 |
| | 60 | 3.98 | 7.68 | 8.95 | 7.77 | 12.93 | 15.45 | 0.362 | 2.739 | 1.087 | 1.810 | 1.452 | 4.429 |
| | 80 | 4.27 | 8.88 | 9.20 | 8.00 | 13.44 | 16.88 | 0.440 | 3.826 | 0.918 | 2.142 | 1.358 | 5.968 |
| 16 | 0 | 3.41 | 6.83 | 7.40 | 7.20 | 10.84 | 13.83 | 0.464 | 3.258 | 0.912 | 1.588 | 1.376 | 4.846 |
| | 20 | 3.58 | 6.22 | 8.05 | 7.57 | 11.63 | 13.79 | 0.491 | 3.239 | 0.819 | 1.674 | 1.310 | 4.913 |
| | 40 | 3.67 | 8.40 | 8.45 | 8.00 | 12.12 | 16.40 | 0.513 | 3.672 | 0.935 | 1.823 | 1.448 | 5.795 |
| | 60 | 3.70 | 9.03 | 8.93 | 8.23 | 12.63 | 17.26 | 0.479 | 4.247 | 1.043 | 1.587 | 1.522 | 5.834 |
| | 80 | 3.90 | 9.64 | 9.08 | 8.33 | 12.98 | 17.97 | 0.408 | 4.071 | 0.963 | 1.691 | 1.371 | 5.962 |
| SD at 5 % level | | | 0.06 | N.S | N.S | N.S | 0.719 | N.S | 0.030 | 0.940 | 0.082 | 0.570 | 0.719 |

**Table 4:** Effect of nitrogen fertilizer and irrigation intervals on water use efficiency of sorghum plants

| Irrigation intervals day | Water Use Efficiency (Kg/M3.) | Water Use Efficiency (Kg/M3.) | | | | | |
|---|---|---|---|---|---|---|---|
| | | 1st cut | | 2nd cut | | Mean | |
| | | 2nds | 1sts. | 2nds | 1sts | 2nds. | 1st s |
| 7 | 0 | 3.64 | 2.87 | 0.58 | 0.90 | 2.11 | 1.89 |
| | 20 | 2.97 | 3.34 | 0.39 | 1.03 | 1.68 | 2.19 |
| | 40 | 3.17 | 3.53 | 0.41 | 0.35 | 1.79 | 1.94 |
| | 60 | 3.30 | 4.02 | 0.40 | 1.42 | 1.85 | 2.72 |
| | 80 | 3.52 | 4.25 | 0.45 | 1.76 | 1.99 | 3.01 |
| | Mean | 3.32 | 3.60 | 0.44 | 1.09 | 1.88 | 2.35 |
| 10 | 0 | 3.51 | 3.76 | 0.49 | 1.22 | 2.00 | 2.49 |
| | 20 | 3.37 | 4.05 | 0.47 | 1.33 | 1.92 | 2.69 |
| | 40 | 3.89 | 4.38 | 0.50 | 1.33 | 2.19 | 2.66 |
| | 60 | 4.10 | 5.11 | 0.52 | 1.51 | 2.31 | 3.31 |
| | 80 | 4.29 | 5.36 | 0.51 | 1.85 | 2.40 | 3.61 |
| | Mean | 3.83 | 4.53 | 0.50 | 1.45 | 2.17 | 2.99 |
| 13 | 0 | 3.99 | 4.14 | 0.50 | 1.06 | 2.25 | 2.60 |
| | 20 | 4.37 | 4.60 | 0.52 | 1.39 | 2.45 | 3.00 |
| | 40 | 4.60 | 5.13 | 0.59 | 1.53 | 2.60 | 3.33 |
| | 60 | 4.79 | 5.72 | 0.54 | 1.64 | 2.67 | 3.68 |
| | 80 | 4.98 | 6.25 | 0.50 | 2.58 | 2.74 | 4.42 |
| | Mean | 4.55 | 5.17 | 0.53 | 1.64 | 2.54 | 3.41 |
| 16 | 0 | 4.52 | 5.76 | 0.57 | 2.02 | 2.55 | 3.89 |
| | 20 | 4.82. | 5.75 | 0.55 | 2.05 | 2.67 | 3.90 |
| | 40 | 5.05 | 6.87 | 0.60 | 2.83 | 2.83 | 4.85 |
| | 60 | 5.26 | 7.19 | 0.63 | 2.85 | 2.95 | 5.02 |
| | 80 | 5.41 | 7.49 | 0.57 | 2.49 | 2.99 | 4.99 |
| | Mean | 5.01 | 6.61 | 0.58 | 2.45 | 2.78 | 4.53 |
| Mean values of nitrogen fertilizer | 0 | 3.92 | 4.13 | 0.54 | 1.30 | 2.23 | 2.72 |
| | 20 | 3.88 | 4.44 | 0.48 | 1.45 | 2.18 | 2.95 |
| | 40 | 4.18 | 4.72 | 0.52 | 1.51 | 2.35 | 3.12 |
| | 60 | 4.36 | 5.51 | 0.52 | 1.86 | 2.44 | 3.69 |
| | 80 | 4.55 | 5.84 | 0.51 | 2.92 | 2.53 | 4.38 |