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# EFFECT OF FERTIGATION METHODS ON PRODUCTIVETY AND NITROGEN USE EFFICIENCY FOR WHEAT AND BARLEY CROPS

**M. A. Kassem* and A. AL-Suker****

## ABSTRACT

*The current study was carried out at Agricultural and Veterinary Research Station, Faculty of Agriculture and Veterinary Medicine, Qassim University, Kingdom of Saudia Arabia during 2006/07 and 2007/08 wheat and barley growing seasons. The objective of this study is to investigate the effect of fertigation and hand broadcasting methods on: uniformity coefficient of water "CUw", uniformity coefficient of nitrogen "CUn", productivity, water use efficiency "WUE" and nitrogen use efficiency "NUE" of wheat and barley crops. Fertigation methods were included injection pump (**IP**), venture (**VE**) and differential pressure tank (**DP**). The results indicated that fertigation methods affected all parameters of this study. Injection pump method then venture method had the highest values of "CUw", "CUn", productivity,"WUE" and "NUE" of wheat and barley crops. While hand broadcasting method had the lowest values of these parameters. In wheat crop, injection pump and venturuy methods had the tallest plants, highest number of spikes m$^{-2}$, number of spikelets spike-1, heaviest kernel weight and highest values of grain and biological yields, while, control treatment gave the lowest values for these traits.*

## INTRODUCTION

In dry land irrigated agriculture, nitrogen becomes the most limiting factor for crop productivity. To improve efficiency of costly nutrients, fertilizer placement and method of fertilizer application under rainfed conditions needs to be investigated for increasing per area yield.

* Assoc. Prof., of Ag. Eng. Dept., Fac. Ag.., Cairo Univ.
** Assis. Prof of crop prod., Fac. Agric & Veter. Medic., Qassim Univ

Application of chemical fertilizers has played a pivotal role in increasing crop production all over the world. Among other agronomic practices that influence the efficiency of applied fertilizer, time and method of application are also critically important **(*Alam, et al., 2005*).** Fertilizers should be applied in a form that becomes available in soil with crop demand for maximum utilization of nitrogen from fertilizers. The method of application is one of the several factors that affects fertilizer use efficiency ***(Mohammad et al. 1999***). ***Feigin et al. (1982)*** reported that fertigation (combined irrigation and fertilization) is the most efficient method of fertilizer application. The hypothesis is that nitrogen use efficiency can be influenced by a fertigation scheme, because movement and transformations of fertigated nitrogen are affected by applications **(*Cote et al. 2003)***. Fertigation enables the application of soluble fertilizers and other chemicals along with irrigation water, uniformly and more efficiently ***(Patel and Rajput 2000)***. The method of fertilizer application is very important in obtaining optimal use of fertilizer. It is recommended that fertilizer should be applied regularly and timely in small amounts ***(Neeraja et al. 1999).*** This will increase the amount of fertilizer used by the plant and reduce the amount lost by leaching ***(Shock et al. (1995***). crop, maximum grain yield of maize was obtained where nitrogen was applied by fertigation method ***(Latif et al. 2001).***

Modern irrigation with suitable chemigation technology, safe and efficient chemigation would provide significant benefits in improving crop productivity and cost effectiveness while minimizing environmental impact ***(El-Gindy 1995).*** Chemicals application through sprinkler irrigation can be achieved by different methods. The most common of which are: injection pump, venture and pressure differential tank, ***(Nakayama and Buks 1986).*** The major disadvantages associated with the use of injection pump are high initial cost, greater maintenance and consequently high costs of production. However pressure differential method which operating on the principle of pressure difference generated by means of valves or venture, causes pressure head loss in operation pressure (***Narda and Chawla 2002***). Fertigation devices can be affected on the uniformity of water and fertilizer, pressure differential tank decrease the uniformity of water and fertilizer in drip irrigation system ***(Bakeer 2002).***

As fertilizer is a costly input and the fertilizer use efficiency under local soil and climatic conditions are low, maximum use efficiency should be the target for high economic returns. Therefore, the present study was conducted to, (1) determine the fertilizer uniformity coefficient for different fertigation methods, (2) find out the best method of fertigation for obtaining higher wheat and barley yields, (2) evaluate the nitrogen use efficiency of wheat and barley and the effects of different fertigation schemes.

## MATERIALS AND METHODS

The field experiments were conducted during 2006/07 and 2007/08 wheat and barley growing seasons at Experimental Farm of the College of Agriculture and Veterinary Medicine, Al-Qassim University. The research farm is located at an altitude of 725m and is intersected by 26º 18' N latitude and 43º 58' E longitude, in central Saudi Arabia. Some physical and chemical properties of the soil surface layer (0–15 cm) determined before the initiation of the experiment during 2006/2007 are presented in Table (1). The irrigation water was obtained from local well. The irrigation water has a pH of 7.4 and total soluble salts of 850 ppm. Sodium adsorption ratio (SAR) value was 2.41.

**Table (1): Physical and chemical characteristics of the experimental soil field.**

| Mechanical analysis | | | Chemical analysis | | | |
|---|---|---|---|---|---|---|
| Sand% | Silt % | Clay % | Ec($DSm^{-1}$) | pH | N(ppm) | K (ppm) |
| 96.1 | 1.8 | 1.9 | 2.4 | 8.2-8.6 | 13-17 | 12-18 |

In the present investigation, two adjacent experiments were carried out, one planted by wheat (**Yecora Rojo cultivar**) and the other by barley (**Justo cultivar**). The treatments comprised of three methods of fertigation (combined irrigation and fertilization) as well as hand broadcast on the surface of the soil, (traditional method- control). The different methods of fertilizer applications were used as following, i.e. hand broadcasting, differential pressure tank, venture and injection pump, ***HB***, ***DP***, ***VE***, and ***IP***, respectively.

Experiments were grown on 25th, 27th, November in both seasons using one factor randomized complete block design with three replications for each experiment. The area of each plot was $3m^2$. All other cultural practices were applied as recommended for wheat and barley cultivation in Al-Qassim Region.

Sprinkler irrigation system was designed and built for this experimental field. Pressure regulator, fertigation device, strangulation valve, two pressure gauges, one before strangulation valve and another after it, and discharge rate gauge were fixed at the inlet for each treatment. Discharge rate gauge was used to estimate the amount of applied water, while the pressure gauges were used to estimate the operating pressure before and after strangulation valve during irrigation and fertigation processes. The sprinklers were spaced at fixed distance 3.0 m apart in a square pattern with precipitation rate of 22.0 mm/h. Four sprinklers applied irrigation water to an experimental plot using a spray angle $90^o$ during irrigation. The height of the riser was 120 cm.

Depth of irrigation water (d) was estimated by multiplying actual evapotranspiration (ETc) for different months by irrigation interval (I), ($d = ETc \times I$). The actual evapotranspiration was estimated and adjusted at the beginning of each growth stage by multiplying reference evapotranspiration for different months by crop coefficient ($ETc = ET_0 \times K_C$) based on crop growth stages. Reference crop evapotranspiration ($ET_0$) was calculated on a daily basis by using Penman–Monteith's formula ***(Smith, 1991)***. The crop coefficient of wheat and barley adopted during the crop season 2006 and 2007 were 0.55 (0; 20 days after grown)) - 0.65 (21; 50 days) - 1.15 (51; 100 days) - 0.30 (101-125 days), according to ***Mustafa et al. (1989).*** Nitrogen at a rate of 300 kg/ha for wheat and 200 kg/ha for barley crop were applied through sprinkler irrigation (fertigation) and hand broadcast treatments. Urea (N content of 46%) was applied every week for each treatment**.** The duration of fertigation was determined by the rule of quarter-half- quarter **(*Burt et al. 1998*)**

To determine the uniformity of irrigation water and fertilizers for the sprinkler irrigation system, 120 mm diameter and 200 mm height catch cans were distributed and spaced at 1.0 meter distance apart in a square pattern. These catch cans were used to collect the irrigation water and amounts of fertilizer dissolved with irrigation water through fertigation presses. The vertical distance between the sprinkler head and catch cans was 90 cm  The necessary weather data were collected from automated weather station was installed  300 m from the experimental field to monitor wind speed and direction, air temperature and relative humidity.

The uniformity of sprinkler irrigation is usually quantified by the coefficient of uniformity proposed by Christiansen **(*Christiansen, 1942*):**

$$CU = \left(1 - \frac{\sum_{i=1}^{n} |X_i - \bar{X}|}{n\bar{X}}\right) \times 100 \qquad \text{Eq.1}$$

where, CU, Xi, $\bar{X}$, and n are Christiansen's coefficient of uniformity in percent, the value of the parameter measured at point i of the measurement grid, the mean value of the parameter measured and the number of measurements, respectively.

The Christiansen uniformity coefficient of water "CUw" and fertilizer "CUf" were estimated for first eight irrigations only during December month. The first fertigation was conducted with irrigation events of 5 December. Urea was applied with a rate of 7.4 $gm.m^{-2}$ and 4.95 $gm.m^{-2}$ for wheat and barley plants, respectively.

Electric conductivity (EC) of fertilizer solution caught in each can was tested by a portable conductivity probe as fertigation was completed. The relationships between concentration of fertilizer solution and EC were calibrated for the fertilizers used prior to fertigation and the following equations were obtained:

$$C = 1.05\ EC - 814 \qquad (n = 12,\ r^2 = 0.999) \qquad Eq.2$$

where C is the concentration of fertilizer solution (ppm), ranging from 0 to1800 ppm ; EC is the electric conductivity of fertilizer solution (μs/cm); n is the number of samples and r is correlative coefficient. Equation (2) was used to determine the concentration of fertilizer solution for each catch can, the amount of fertilizer applied for each catch can was determined from the concentration of fertilizer solution and the water volume caught in the catch can. Christiansen uniformity coefficient for fertilizer was also calculated by using equation (1)

In both seasons, characters evaluated involved agronomic characters and water and nitrogen use efficiency. Agronomic traits for wheat crop were taken on plant height, number of spikes $m^{-2}$, number of spikelet $spikes^{-1}$, 1000-kernel weight and grain and biological yields. Grain yield was estimated from the four central rows of each plot and converted into ton $hectar^{-1}$. Biological yield was measured using the same way as grain yield. Harvest index was recorded as a ratio of grain yield to the total above ground dry matter of each plot. Moreover, Agronomic traits for barley crop were taken on plant height, and yields and harvest index. These characters were measurement as previous in wheat crop.

The water use efficiency (WUE) and the nitrogen use efficiency (NUE) of wheat and barely crops were determined from equations (3) and (4) according to ***James (1988)***.

$$WUE = (Y / Aw) \qquad Eq.3$$

$$NUE = (Y/N) \qquad Eq.4$$

Where:

WUE = water use efficiency, $kg.m^{-3}$;

NUE = nitrogen use efficiency, $kg.kg^{-1}$;

Y = the crop yield, $kg.m^{-2}$;

Aw = the seasonal amount of applied water, $m^3 .m^{-2}$;

N = the seasonal amount of applied nitrogen, $m^3 .m^{-2}$.

Analysis of variance was used to evaluate the responses of each studied character in both crops. Where a significant F-test was found the mean values were separated using Duncan's multiple range test. All analyses of variance were computed using the MSTATC microcomputer program ***(MSTATC, 1990).***

## <u>RESULTS AND DISCUSSION</u>

### 1. Climatic conditions and sprinkler operating pressure during the experiments.

Table (2) shows the average values of climatic conditions for December month (wind speed, relative humidity and air temperature) during irrigation and fertigiation experiments for first eight irrigations for two seasons. Examination of these parameters shows that climatic parameters wind speed, temperature, and relative humidity did not considerably change during the experiments.

The measurements of sprinkler operating pressure for two years showed insignificant variations between two years. Therefore, Table (3) shows the average values of sprinkler operating pressure for two seasons. The data revealed that the sprinkler operating pressure did not considerably change during irrigation. This constant of operating pressure may be due to the pressure regulator was fixed in the inlet of each treatment. While, during fertigation, the methods of fertigation had highly significant effects on sprinkler operating pressure. The values of sprinkler operating pressure were decreased compared with those during irrigation. Strangulation valve was partially closed during fertigation by using differential pressure tank "***DP***" and venture "***VE***" methods. The sprinkler operating pressure decreased after strangulation valve compared with that before it, as a result of partially closed of strangulation valve. Differential pressure tank "***DP***" method had the highest effect on operation pressure then venture method. The mean values of operating pressure were decreased from 233 and 237.3 kPa before strangulation valve to 180 and 207 kPa after it for differential pressure tank "***DP***" and venture "***VE***" methods, respectively. Injection pump method of fertigation considerably did not effect on sprinkler operating pressure. No surface runoff was observed in the experiments.

## 2. Effect of fertigation methods on uniformity coefficient of water "CUw".

The measurements of uniformity coefficient of water "CUw" for tested irrigation and for two years showed insignificant variations between them. Therefore, fig.(1) shows the mean values of uniformity coefficient of water "CUw" during irrigation and during fertigation. The data revealed that fertigation methods had highly significant effects on uniformity coefficient of water "CUw". During fertigation, the uniformity coefficient of water "CUw" was decreased compared with that during irrigation. Differential pressure tank (***DP***) method had the highest effect on uniformity coefficient of water "CUw" then venture method, while injection pump method of fertigation considerably did not effect on uniformity coefficient of water "CUw". The mean values of uniformity coefficient of water "CUw" were decreased during fertigation by using "***DP***" and "***VE***" methods. The decrease in "CUw" values during fertigation for "***DP***" and "VE" methods may be as a result of decreasing sprinkler operating pressure, (section 1). By decreasing the sprinkler operating pressure the sprinkler discharge rate and "CUw" were decreased **(Bakeer, 2002).** Injection pump and venturui methods had the highest values of uniformity coefficient of water during fertigation "CUw" 79% and 72 %, respectively, while "***DP***" method gave the lowest value of uniformity coefficient of water "CUw" 62%.

## 3. Effect of fertigation methods on uniformity coefficient of nitrogen "CUn".

Fig.(2) shows the mean values of uniformity coefficient of nitrogen "CUn" during fertigation for two seasons. The data revealed that fertigation methods had highly significant effects on uniformity coefficient of nitrogen "CUn". Injection pump and venturui methods had the highest values of uniformity coefficient of nitrogen "CUn" 77% and 70% respectively, while **"*DP*"** method gave the lowest value of uniformity coefficient of nitrogen "CUn" 56%. The decrease in "CUn" during fertigation by using "***DP***" and "***VE***" methods may be as a result of decreasing uniformity coefficient of water "CUw" during fertigation.

**Table (2): Mean values of Climatic conditions during the experiments.**

| Date | Climatic conditions 2006 | | | Climatic conditions 2007 | | |
|---|---|---|---|---|---|---|
| | Wind speed (m/h) | Relative humidity (%) | Temperature (ºc) | Wind speed (m/h) | Relative humidity (%) | Temperature (ºc ) |
| 5 Dec. | 4.00 | 65.0 | 16.00 | 3.90 | 66.0 | 15.00 |
| *8 Dec. | 3.80 | 67.0 | 14.00 | 3.90 | 65.0 | 14.00 |
| 12 Dec. | 4.00 | 66.0 | 15.00 | 4.00 | 67.0 | 14.00 |
| *15 Dec. | 3.70 | 67.0 | 13.00 | 3.80 | 66.0 | 15.00 |
| 19 Dec. | 3.60 | 65.0 | 14.00 | 3.50 | 65.0 | 13.00 |
| *22 Dec. | 3.70 | 62.0 | 12.00 | 3.90 | 68.0 | 13.00 |
| 26 Dec. | 4.00 | 65.0 | 12.00 | 3.90 | 68.0 | 12.00 |
| *30 Dec. | 3.80 | 67.0 | 14.00 | 4.00 | 67.0 | 13.00 |
| Mean values | 3.82 | 65.5 | 13.75 | 3.86 | 66.5 | 13.63 |

* Fertigition applied

**Table (3): Mean values of operating pressure of sprinklers for different fertigation methods during irrigation and firtigation.**

| Date | operating pressure of sprinklers (kPa) *HB* | *DP* | *VE* | *IP* |
|---|---|---|---|---|
| 5 Dec. | 240 | 232 | 230 | 242 |
| *8 Dec. | 230 | 238-180 | 246-212 | 244-247 |
| 12 Dec. | 240 | 243 | 244 | 233 |
| *15 Dec. | 245 | 241-170 | 240-200 | 232-241 |
| 19 Dec. | 244 | 245 | 235 | 244 |
| *22 Dec. | 243 | 241-180 | 237-210 | 240-236 |
| 26 Dec. | 232 | 236 | 246 | 247 |
| *30 Dec. | 239 | 243-190 | 247-215 | 243-247 |
| Mean values | 237.5 | 233-184 | 236.3-207 | 237.5-237 |

- Fertigition applied

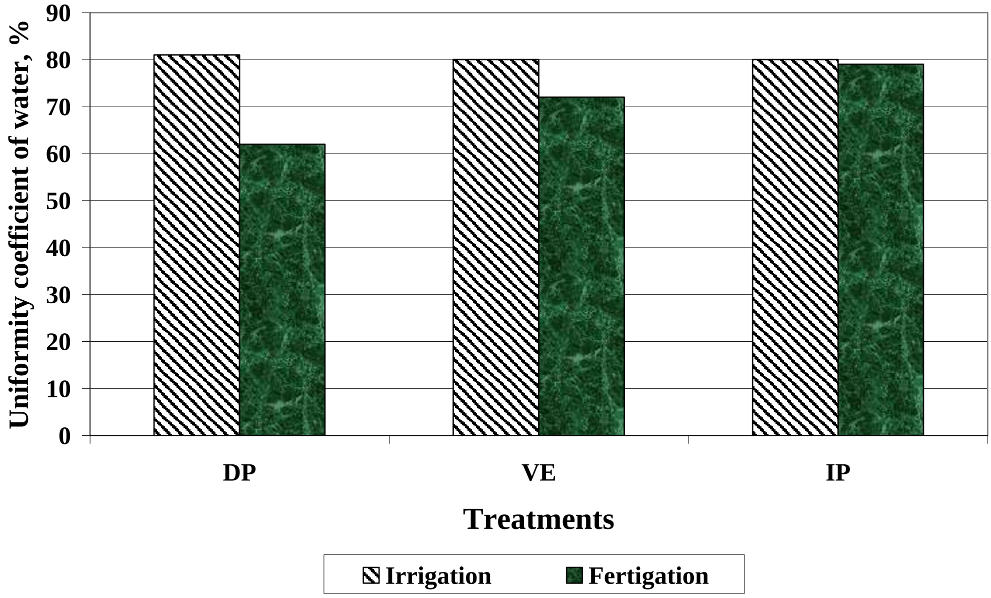


**Fig. (1): Uniformity coefficient of water during irrigation and during fertigation for different fertigation methods.**

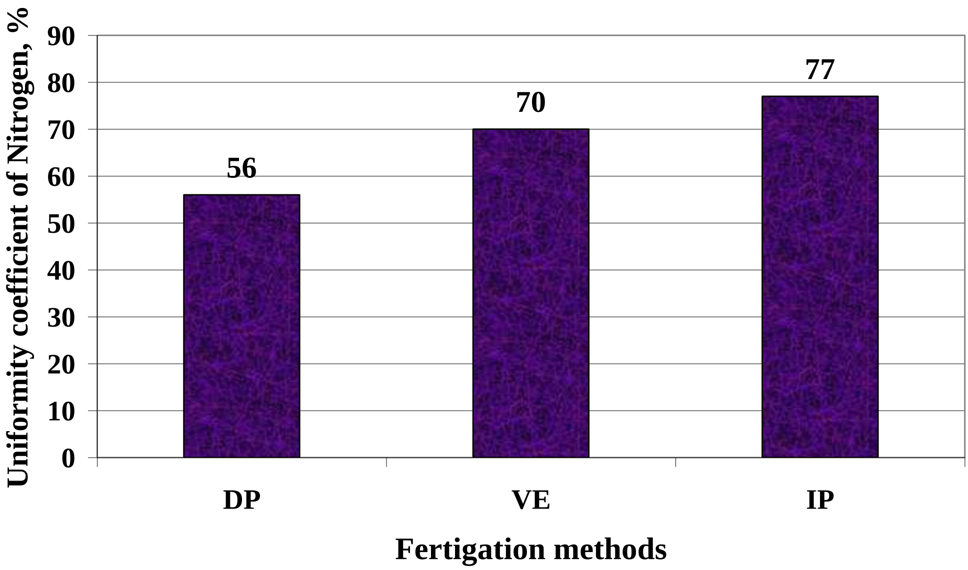


**Fig. (2): Effect of fertigation methods on uniformity coefficient of nitrogen "CUn" during fertigation**.

## 4. Effect of fertigation methods on productivity of wheat and barley crops.

### a- Wheat crop

The analysis of variance for all characters (Table 4 and 6) showed insignificant variations due to year, for all characters. Therefore, the results are discusses in average across two years. Fertigation and hand broadcast (control) methods had highly significant effects on all studied characters. The combined analysis of variance showed insignificant differences of interactions between fertilizer application methods and year for most studied traits (Table 4 and6).

Effect of fertigation and hand broadcast methods (Averaged across two years) on wheat crop for agronomic characters are present in Table 5. Plant height revealed that, injection pump and venturuy methods recorded the tallest plant with insignificant differences between them, while, control method was shortest one. Such increase in plant height may be occurred due to the stimulation of cell division and internode elongation, resulted from increasing nitrogen use efficiency of fertigated methods.

The effect of fertigation and hand broadcast methods on grain yield and its components for wheat crop were highly significant. The data in Table 5 showed that injection pump method recorded the highest number of spikes $m^{-2}$ with significant differences with the other treatments. Meanwhile, control treatment possessed the lowest number of spikes $m^{-2}$. Injection pump and venturuy methods had the highest number of spikelets $spike^{-1}$, 19.5 and 18.9 respectively, while control treatment gave the lowest number of spikelets $spike^{-1}$ with insignificant difference with fertilizer tank method (Table5). The heaviest kernels weight were obtained by applied injection pump method for fertigation (51.3g), while the lightest weight was obtained by used control method (38.5).

Table 5 showed that grain and biological yields were highly significant increased by applied fertigation methods comparing with control. Injection pump method out yielded the all other methods of fertilizer application for grain and biological yields. Such increases in grain yield obtained mainly due to increases in number of spikes $m^{-2}$ and 1000-kernral weight. The increase in wheat grain and biological yields with applied fertigation methods may be as result of producing higher number of spikes $m^{-2}$ and heavy kernels weight which were enhanced and produced by improved nitrogen use efficiency which is a major component in chlorophyll and other cellular constituents of plant.

**Table 4. Analysis of variance "*P*" values for sources of variation for agronomic characters over two years with 4-fertilizer application methods(FM) on wheat crop.**

| SOV | Plant height | Spikes. $m^{-2}$ | Spikelet $Spike^{-1}$ | 1000-Kernel weight | Grain yield | Biological yield | Harvest index |
|---|---|---|---|---|---|---|---|
| Year (Y) | 0.121 | 0.348 | - | - | 0.190 | - | 0.09 |
| FM | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Y ×FM | 0.107 | 0.361 | 0.323 | 0.004 | 0.091 | 0.006 | - |
| CV % | 1.40 | 3.99 | 5.96 | 1.30 | 3.18 | 1.86 | 4.13 |

**Table 5. Effect of fertigation and hand broadcasting methods on agronomic characters for wheat crop (2-years average)**

| Treatment | Plant height (cm) | Spikes ($m^{-2}$) | Spikelet $Spike^{-1}$ | 1000-Kernel weight | Grain yield (kg $ha^{-1}$) | Biological yield (kg $ha^{-1}$) | Harvest index |
|---|---|---|---|---|---|---|---|
| ***HB*** | 61.8c | 392.3d | 16.1b | 38.5d | 2155d | 4872d | 0.44b |
| ***DP*** | 67.3b | 449.8c | 17.2b | 44.3c | 2487c | 5422c | 0.46b |
| ***VE*** | 70.9a | 507.0b | 18.9a | 49.5b | 3217b | 5942b | 0.54a |
| ***IP*** | 71.9a | 534.0a | 19.5a | 51.3a | 3403a | 6343a | 0.54a |

***HB, DP, VE***, and ***IP***= hand broadcasting, differential pressure tank, venture and injection pump, respectively.
means designated by the same latter are not statistically different at $P<0.05$ level according to Duncan's Multiple Range Test**.**

Such increase in biological yield was obtained by improved nitrogen use efficiency in more likely due to the obtained increase in plant height and number of spikes $m^{-2}$. These results are in close agreement with those obtained by ***Akhtar et al (2002)*** and ***Rajuput et al., (2004).*** Nitrogen application methods had significant effect on harvest index. The data showed that the highest harvest index was obtained by injection pump method and venturuy while, the lowest one was by using control method. The increase in wheat grain and biological yields with fertigation by injection pump method may be as result of increasing the values of uniformity coefficient of water "CUw" and nitrogen "**CUn**" for this method. Our findings agree with the results of ***Alam et al.,(2005)*** who found that fertigation applied N and P fertilizers increased grain yield in wheat.

**b-Barley crop**

The analysis of variance for agronomic characters (Table 6) showed insignificant variations due to years, for all characters. Therefore, the results are discussed across two years. Effect of fertigation and hand broadcast methods were highly significant for all studied characters for barley crop (Table 6)

**Table 6. Analysis of variance "*P*" values for sources of variation for agronomic characters over two years with 4-fertilizer application methods on barley crop.**

| SOV | Plant height | Grain yield | Biological yield | Harvest index |
|---|---|---|---|---|
| Year (Y) | 0.630 | 0.173 | 0.155 | 0.217 |
| Fertigation (F) | 0.000 | 0.000 | 0.000 | 0.000 |
| YF | 0.212 | 0.142 | 0.229 | - |
| CV % | 2.37 | 3.16 | 2.30 | 3.09 |

Data presented in Table 7 show the effect of fertigation and hand broadcast methods on agronomic characters. The mean values of plant height for barley crop were significantly increased by fertigation methods comparing with hand broadcasting method. The injection pump and venturuy methods recorded the tallest plant with insignificant differences between them, while hand broadcasting method had the shortest plant (Table 7). This result assuring the similar previous results for wheat crop, and could be attributed to the stimulation of cell division and internodes elongation, resulted from increasing nitrogen use efficiency of fertigated methods.

Regarding grain and biological yields, in general, applying fertigation methods increased these characters comparing with hand broadcasting method. Injection pump method out yielded all the other methods of fertigation, while, hand broadcasting method gave the lowest yields (Table 7). Increasing grain and biological yields with using fertigation methods had attributed to the increase in yield components values such as number of spikes $m^{-2}$, and 1000-kernel weight (data no presented). The data showed that the highest harvest index was obtained by using Injection pump method followed by venture The increase in barley grain and biological yields with fertigation by injection pump method may be as result of increasing the values of uniformity coefficient of water "CUw" and nitrogen "**CUn**" for this method. Many investigators reported higher yield and water use efficiency for other crops by applying fertigation methods, in maize **(Latif et al.,2001),**tomato **(Kaviani et al., and Hebber et al.,2004),** potato **(Darwish et al., 2006 and Janat,2007)** and cotton **(hou et al.,2007).**

**Table 7. Effect of fertigation and hand broadcasting methods on agronomic characters for barley crop (2-years average)**

| Treatment | Plant height (cm) | Grain yield (kg $ha^{-1}$) | Biological yield (kg $ha^{-1}$) | Harvest index |
|---|---|---|---|---|
| ***HB*** | 58.8c | 1648d | 3483d | 0.47b |
| ***DP*** | 67.2b | 1805c | 3875c | 0.47b |
| ***VE*** | 71.1a | 2375b | 4350 b | 0.55a |
| ***IP*** | 72.8a | 2577a | 4575a | 0.56a |

***HB, DP, VE***, and ***IP***= hand broadcasting, differential pressure tank, venture and injection pump, respectively. means designated by the same latter are not statistically different at $P<0.05$ level according to Duncan's Multiple Range Test

### 5. Effect of fertigation methods on water and nitrogen use efficiency of wheat and barley crops.

Based on the combined analysis of variance, the mean squares of year (Y) for water and nitrogen use efficiency measurements were insignificant differences in most cases (Table 8). The main effect of fertilizer application methods was highly significant for studied traits. The analysis of variance showed insignificant differences of interactions between years and fertilizer application methods for all characters (Table 8).

**Table 8. Analysis of variance "*P*" values for sources of variation for water and nitrogen use efficiency over two years with 4-fertilizer application methods on wheat and barley crops.**

| | Wheat | | Barley | |
|---|---|---|---|---|
| **SOV** | **WUE** | **NUE** | **WUE** | **NUE** |
| Year (Y) | 0.241 | - | 0.024 | 0.054 |
| Fertigation (F) | 0.000 | 0.000 | 0.000 | 0.000 |
| YF | - | - | 0.154 | 0.406 |
| CV % | 3.36 | 1.97 | 1.40 | 1.10 |

Data presented in (table 9) show the effect of fertigation and hand broadcast methods on water and nitrogen use efficiency. the mean values of water use efficiency "WUE" for wheat and barley crop were significantly increased by fertigation methods comparing with hand broadcasting method. The injection pump method recorded the highest values of water and nitrogen use efficiency with significant differences with other treatments. Meanwhile hand broadcasting method had the lowest values of water and nitrogen use efficiency (Table 9).

**Table 9. Effect of fertigation and hand broadcasting methods on water and nitrogen use efficiency characters for wheat and barley crops (2-years average)**

| **Treatment** | **Water use efficiency ($Kg.m^{-3}$)** | | **Nitrogen use efficiency ($kg.kg^{-1}$)** | |
|---|---|---|---|---|
| | **Wheat** | **Barley** | **Wheat** | **Barley** |
| ***HB*** | 0.91d | 0.62d | 16.0d | 12.3d |
| ***DP*** | 1.00c | 0.67c | 17.1c | 14.7c |
| ***VE*** | 1.09b | 0.75b | 19.4b | 16.5b |
| ***IP*** | 1.14a | 0.79a | 20.8a | 17.2a |

***HB, DP, VE,*** and ***IP***= hand broadcasting, differential pressure tank, venture and injection pump, respectively. means designated by the same latter are not statistically different at $P<0.05$ level according to Duncan's Multiple Range Test.

For wheat crop, injection pump method had the highest values of "WUE" and "NUE" 1.14 $kg.m^{-3}$ and 20.8 $kg.kg^{-1}$, respectively. While the lowest values of "WUE" and "NUE" 0.91 $kg.m^{-3}$and 16.0 $kg.kg^{-1}$, respectively. For barley crop, injection pump method had the highest values of "WUE" and "NUE" 0.79 $kg.m^{-3}$ and 17.2 $kg.kg^{-1}$, respectively. While the lowest values of "WUE" and "NUE" 0.62 $kg.m^{-3}$ and 12.3 $kg.kg^{-1}$, respectively.

## CONCLUSION

The purpose of this research work is to explore the effect of fertigation and hand broadcasting methods on: uniformity coefficient of water "CUw", uniformity coefficient of nitrogen "CUn", productivity, water use efficiency "WUE" and nitrogen use efficiency "NUE" of wheat and barley crops. The treatments comprised of three methods of fertigation as well as hand broadcast on the surface of the soil, (control). The different methods of fertilizer applications were used as following, i.e. hand broadcasting, differential pressure tank, venture and injection pump, ***HB***, ***DP, VE,*** and ***IP***, respectively. The results indicated that:

**1.** The mean values of sprinkler operating pressure were decreased from 233 and 237.3 kPa before strangulation valve to 180 and 207 kPa after it for differential pressure tank "***DP***" and venture "***VE***" methods, respectively.

2. Injection pump and venturui methods had the highest values of uniformity coefficient of water during fertigation "**CUw**" 79% and 72 %, respectively, while differential pressure tank method gave the lowest value of uniformity coefficient of water "**CUw**" 62%.

**3.** Injection pump and venturui methods had the highest values of uniformity coefficient of nitrogen "**CUn**" 77% and 70% respectively, while differential pressure tank method gave the lowest value of uniformity coefficient of nitrogen "**CUn**" 56%.

**4.** IN wheat crop, injection pump and venturuy methods had the tallest plants, highest number of spikes $m^{-2}$, number of spikelets $spike^{-1}$, heaviest kernel weight and highest values of grain and biological yields, while, hand broadcasting method gave the lowest values for these traits.

**5.** The mean values of grain and biological yields of wheat and barley crops were significantly increased by fertigation methods comparing with hand broadcasting method. The injection pump and venture methods recorded the highest grain yield with significant differences between them, while hand broadcasting method had the lowest grain yield.

**6.** For wheat crop, injection pump method had the highest values of "**WUE**" and "**NUE**" 1.14 $kg.m^{-3}$ and 20.8 $kg.kg^{-1}$, respectively. While hand broadcasting method had the lowest values of "WUE" and "NUE" 0.91 $kg.m^{-3}$ and 16.0 $kg.kg^{-1}$, respectively.

7. For barley crop, injection pump method had the highest values of "**WUE**" and "**NUE**" 0.79 $kg.m^{-3}$ and 17.2 $kg.kg^{-1}$, respectively. While hand broadcasting method had the lowest values of "**WUE**" and "**NUE**" 0.62 $kg.m^{-3}$ and 12.3 $kg.kg^{-1}$, respectively.

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## الملخص العربي

# تأثير طرق حقن السماد مع مياه الري على إنتاجية وكفاءة استخدام المياه والنتروجين لمحصولي القمح والشعير

**محمد عبد الوهاب قاسم* - عبد الرحمن الصقير****

أجريت هذه الدراسة الحقلية بمحطة التجارب الزراعية والبيطرية بكلية الزراعة والطب البيطري - جامعة القصيم. خلال موسمي ٢٠٠٦ / ٢٠٠٧ , ٢٠٠٧ /٢٠٠٨ م - وذلك لدراسة تأثير طرق حقن السماد مع مياه الري على ضغط تشغيل الرشاشات , انتظامية توزيع المياه "CUw" , انتظامية توزيع النتروجين "CUn" , الإنتاجية , كفاءة استخدام المياه "WUE" وكفاءة استخدام النتروجين "NUE" لمحصولي القمح والشعير مقارنة بطريقة التسميد اليدوية- مع تحديد انسب طريقة لحقن السماد مع مياه الري عند تسميد محصولي القمح والشعير. ولتحقيق أهداف هذه الدراسة تم استخدام ثلاثة طرق لحقن السماد مع مياه الري هي: " تنك فرق الضغط والفنشوري و مضخة الحقن" بالإضافة إلى التسميد اليدوي نثرا للمقارنة (كنترول).

* أستاذ الهندسة الزراعية المشارك - كلية الزراعة-جامعة القاهرة.

** أستاذ إنتاج المحاصيل المساعد- كلية الزراعة والطب البيطري- جامعة القصيم

**وقد أظهرت الدراسة ما يلى:-**

١. يتأثر ضغط تشغيل الرشاشات أثناء حقن السماد بطريقة الحقن المستخدمة, حيث ينخفض ضغط تشغيل الرشاشات أثناء حقن السماد لكل من طريقتي تنك فرق الضغط "***DP***" والفنشوري "***VE***", في حين لم ينخفض ضغط التشغيل عند حقن السماد بمضخة الحقن "***IP***" . أنخفض ضغط التشغيل للرشاشات من ٢٣٣ و ٢٣٧,٢ كيلو باسكال قبل محبس الخنق إلى ١٨٠ و ٢٠٧ كيلو باسكال لكل من طريقتي تنك فرق الضغط "***DP***" والفنشوري "*VE*" على الترتيب.

٢. يتأثر انتظام توزيع المياه "CUw" أثناء حقن السماد بطريقة الحقن المستخدمة, حيث تحققت أعلى قيمة لانتظام توزيع المياه "CUw" أثناء حقن السماد لكل من طريقتي مضخة الحقن "***IP***" " والفنشوري "*VE*" ٧٩٪ و ٧٢٪ على الترتيب, بينما أقل قيمة كانت ٦٢٪ لمعاملة حقن السماد بطريقة تنك فرق الضغط "***DP***".

٣. يتأثر انتظام توزيع النتروجين "CUn" أثناء حقن السماد بطريقة الحقن المستخدمة, حيث تحققت أعلى قيمة لانتظام توزيع النتروجين "CUn" أثناء حقن السماد لكل من طريقتي مضخة الحقن "***IP***" والفنشوري "***VE***" ٧٧٪ و ٧٠٪ على الترتيب, بينما أقل قيمة كانت ٥٦٪ لمعاملة حقن السماد بطريقة تنك فرق الضغط "***DP***".

٤. تحقق أعلى قيم لارتفاع النبات، وعدد السنابل للمتر المربع، عدد للسنيبلات بكل سنبلة و وزن الـ١٠٠٠ حبة في محصول القمح لمعاملتي حقن السماد باستخدام مضخة الحقن "***IP***" والفنشوري "***VE***", بينما كانت أقل القيم لهذه الصفات لمعاملة التسميد اليدوي نثرا (الكنترول).

٥. يزداد محصول الحبوب والبيولوجي لمحصول القمح بدرجة معنوية بطرق حقن السماد مع مياه الري مقارنة بطريقة التسميد اليدوية. تحقق أعلى محصول لحبوب القمح لكل من طريقتي مضخة الحقن "***IP***" " والفنشوري "***VE***" بينما أقل قيمة كانت لمعاملة التسميد اليدوي نثرا (الكنترول).

٦. يزداد محصول الحبوب لمحصول الشعير بدرجة معنوية بطرق حقن السماد مع مياه الري مقارنة بطريقة التسميد اليدوية. تحقق أعلى محصول لحبوب الشعير لكل من طريقتي مضخة الحقن "***IP***" " والفنشوري "***VE***", بينما أقل قيمة كانت لمعاملة التسميد اليدوي نثرا (الكنترول).

٧. تحققت أعلى قيم لكفاءة استخدام المياه "WUE" وكفاءة استخدام النتروجين "NUE" لمحصول القمح عند حقن السماد بمضخة الحقن "***IP***" ١,١٤ كجم.م$^{-٣}$ و ٢٠,٨ كجم.كجم$^{-١}$ على الترتيب, بينما أقل قيم كانت ٠,٩١ كجم.م$^{-٣}$ و ١٦ كجم.كجم$^{-١}$ لمعاملة التسميد اليدوي نثرا (الكنترول).

٨. تحققت أعلى قيم لكفاءة استخدام المياه "WUE" وكفاءة استخدام النتروجين "NUE" لمحصول الشعير عند حقن السماد بمضخة الحقن "***IP***" ٠,٧٩ كجم.م$^{-٣}$ و ١٧,٢ كجم.كجم$^{-١}$ على الترتيب, بينما أقل قيم كانت ٠,٦٢ كجم.م$^{-٣}$ و ١٢,٣ كجم.كجم$^{-١}$ لمعاملة التسميد اليدوي نثرا (الكنترول).