ISSN 1110-0419

Annals Of Agric. Sc., Moshtohor,
Vol. 42(2): 439-448, (2004).

IMPLICATION OF HISTORICAL WEATHER DATA ON WHEAT YIELD PREDICTION SOWN UNDER DIFFERENT SOWING DATES AT MIDDLE EGYPT REGION

BY

Samia. G. A. Mohamed; Sohier M. Swilam and Abd El-Aziez, A. M.
Central Laboratory for Experimental Design and Statistical Analysis: Agriculture Research Center

ABSTRACT

This work is concerned with: i) developing regression equations to make future predication of wheat yield and (ii) to test the validity of these equations. Yield data covering the period (1977-2003) were regressed on averages temperature, solar radition and amount of precipitation at El-Fayoum Govenorate for the some period. Four equations, to link yield with sowing date each pertaining to a growth stage of the crop were thus developed. Tp verify these equations, wheat yields from two seasons experiment including the cultivars Sakha 69, Sids 1, Sakha 93, Giza 169, and Gemmeiza 7 were used. Predicted yields were compared with actual yields of these cultivars. In addition, weather parameters (1999-2000) were utilized to predict wheat yields for there seasons in a row. Predicted yield were also comparad with actual ones. Results indicated the applicability of the equation in the prediction of yield with great precision. As for cultivars, results indicated that they were quite comparable in productivity, if grown no later them the last week of November. In case of delay till the second week of December, it is recommened to grow Gemmeiza 7, Sakha 69 or Sids 1. In very late sowings, the fourth week of December, it is preferable to grow either Gemmeiza 7, or Sakha 69.

INTRODUCTION

Wheat is one of the most imporatnt cereal crops in Egypt, and increasing yield of wheat is essential to meet the increasing demand for it. Egypt imports up to 50% of the total consumption. Predicting wheat yield, specially under different sowing dates is very useful in determining the total amount of wheat to be imported. A simple and accurate procedure was used to predict wheat yield by utilizing weather parameters as predictors. Swilam *et al.* (2004) used historical weather data to develop equations to predicte wheat yield in Delta Region

Solar radiation and temperature are two weather variable that have direct and significant effect on crop production (Gardner *et al.* 1985). Temperature affects the duration of crop growth (Wilhelm and McMaster, 1995); consequently influences: yield (McMaster, 1997) Number of tillers is usually decreased when

wheat plants were exposed to high temperature, which occurred when sowing is delayed (Friend 1965). In addition, temperature is the major variable controlling spikelet initiation and development rates (McMaster, 1997). Wiegand and Cuellar (1981) found that high temperature during grain filling in wheat usually reduces average kernel weight. The duration of grain filling period was also reduced (Sofield *et al.*, 1977), as well as growth rates with a net effect of lower final kernel weight (Bagga and Rawson 1977).

Delay wheat sowing up to December exposes plants to high temperature, reduce season length and concequently, reduces yield (Eid *et al.*, 1997; El-Marsafawy *et al.*, 1998; Rayan *et al.*,1999).

Therefore the objectives of this work are to develop regression equations to predict wheat yield using weather data at Middle Egypt region under different sowing dates and to test the validity of these equations under different conditions.

MATERIALS AND METHODS

1. Data collection

Wheat yield (Ardab/fed) values were collected for Middle Egypt region for the period from 1977-2003. Data for mean temperature (Mtemp, ° C), solar radiation (SR, cal/cm^2/day), and rain (mm) were collected for the period of (1977-2003) for El-Fyoum Governorate (as a representative of Middles Egypt region). These weather parameters were used to predict wheat yield. Three sowing dates were assumed (November, 26; December, 11; December, 26) and season length was assumed to be 170, 158, and 147 days for the above mentioned sowing dates, respectively as indicated by Eid *et al.*, (1999). For each sowing date, weather parameters of twenty three years (1977-2000) were used to develop one prediction equation for wheat yield.

Moreover, four growth stages were studied i.e. from planting to the end of tillering, from planting to the end of booting, from planting to the end of anthesis, and from planting to the end of grain filling. Tillering occurs about 45-50 days after planting and booting occurs about 80-85 days after planting. Anthesis takes place about 5-10 days and grain filling period occurs about 85-95 days after planting. Mean temperature, mean solar radiation and mean rain were summed for each growth stage and throughout the growing season. Weather parameters for twenty three years (1977-2000) were used to develop one prediction equation for each growth stages to predict wheat yield.

2. Statistical procedure

The multiple linear regression technique was used to develop prediction equations for vareities and seasons wheat yield, as a function of weather parameters.. To determine the goodness of fit, the two parameters, coefficient of determination (R^2) and standard error of estimates (SE%).were calculated. In order to obtain a precise prediction, two restrictions were made, the R^2 should be near to one and SE% should be near to zero. R^2 is the amount of variability due to

all independent variables, and SE% is a measurement of precision i. e. closeness of predicted and observed yield to each other (Draper and Smith, 1987).

Estemation of percent decrease% (PD%) as follow:

PD%= [(actuale yield – predect yield) / actuale yield] x 100

3. Testing the validity of the prediction equations

3.1. For different Varieties

To test the validity of the developed equations, data for wheat yield from an experiment planted at El-Fyoum in 1998/99 and 1999/2000 growing seasons was used. The data consists of yield of six wheat cultivars i.e. Sakha 69, Sids 1, Sakha 93, and Giza 168, Gemmeiza 7, Gemmeiza 9 (Moshref *et al.*, 2001). Wheat yield was predicted and compared to actual yields of these cultivars. Percent reductions in yield were then calculated

3.2. At different years

In addition, weather parameters of 1999/00 season were used to predict wheat yield and then compared to actual yield of 2000/01. Similarly, the yields of 2001/02 and 2002/03 were predicted using previous weather parameters and then compared to actual yields. Percent reductions in yield were then calculated.

RESULTS AND DISCUSSION

1. Determination of weather parameters

For each of the four growth stages and under each sowing date, mean temperature, solar radiation, and rain were averaged for the studied time period from 1977-2000 (Table 1).

Table (1): Mean temperature, solar radiation, and rain for four growing stages of wheat and under three sowing dates (average over 23 years)

Sowing Dates	End of tillering		
	Mtemp° C	SR cal/cm^2/day	Rain mm
Nov, 26	18.69	346.6	11.4
Dec, 11	17.00	335.2	14.9
Dec, 26	17.9	412.0	8.11
	End of booting		
Nov, 26	16.68	363.90	9.12
Dec, 11	19.54	391.08	9.40
Dec, 26	17.87	415.4	7.01
	End of anthesis		
Nov, 26	17.6	382.9	8.8
Dec, 11	17.49	384.3	8.8
Dec, 26	17.49	423.7	6.7
	End of grain filling		
Nov, 26	18.12	435.7	6.04
Dec, 11	19.39	424.2	6.54
Dec, 26	19.19	457.9	4.98

2. Wheat yield prediction in 1999/2000 growing season

2.1. Prediction equations for wheat sown at November, 26

Results in Table (2) shown that the highest R^2 and the lowest SE% were observed for equation [4]. However, any of the four studied stages was suitable to predict wheat yield because of their high accuarcy i.e. low SE %

Table (2): Prediction equations for different growth stages for wheat sowing at November, 26

Growth stage	Prediction Equation	R^2	SE%
End of tillering	[1]Y`= 30.78-0.49Mtemp**-0.03*Rain-0.02SR**	0.956	5.85
End of booting	[2]Y`=39.56-0.39Mtemp*-0.01Rain-0.05SR**	0.945	6.58
End of anthesis	[3]Y`= 40.13-0.41Mtemp*-0.05Rain*-0.04SR**	0.941	6.79
End of grain fill	[4]Y`=34.05-1.22Mtemp**-0.05Rain+0.004SR	0.965	5.26

2.2. Prediction of wheat yield sown at November, 26

Results in Table (3) showed that percent decrease between actual and predicted yield were between 3.18-9.87 %. The lowest percent decrease was obtained when wheat yield was predicted at the end of grain filling period. This could be attributed to the fact that sowing wheat on November, 26 exposes wheat plant to favorable weather conditions for growth and consequently increase yield. Moreover, end of tillering and end of anthesis could be used to attain early prediction of wheat yield, where PD % were 5.50 and 5.96, respectively. Figure (1) shows line fit between predicted and actual wheat yield planted at November, 26.

Table (3): Actual and predicted yield and percent decrease for wheat sown at November, 26

Growth stage	Actual yield	Predicted yield	Percent decrease
End of tillering	18.99	17.94	5.50
End of booting	18.99	17.11	9.87
End of anthesis	18.99	17.85	5.96
End of grain fill	18.99	18.38	3.18

2.3. Prediction equations for wheat sown at December, 11

Results in Table (4) shown that the highest R^2 and the lowest SE% were observed for equation [8] followed by equation [5].

Table (4): Prediction equations for different growth stages for wheat sowing at December, 11

Growth stage	Prediction Equation	R^2	SE%
End of tillering	[5]Y`=34.82-0.88Mtemp**-0.008Rain-0.02SR**	0.892	7.72
End of booting	[6]Y`=41.71-0.49Mtemp*-0.004Rain-0.04SR**	0.882	8.29
End of anthesis	[7]Y`= 36.95-1.41Mtemp**-0.02Rain-0.004SR	0.87.7	9.41
End of grain fill	[8]Y`=39.77-1.23Mtemp**-0.09Rain-0.004SR	0.906	7.00

2.4. Prediction of wheat yield sown at December, 11

Results in Table (5) showed that percent decrease between actual and predicted yield was between 8.58-13.35 %. Results in that table showed that the lowest percent decrease between predicted and actual wheat yield was obtained when wheat yield was predicted at the end of grain filling period. Moreover, end of tillering could be used for early prediction of yield because of its relatively low PD % (10.26 %). Figure (2) shows line fit between predicted and actual wheat yield planted at December, 11.

Table (5): Actual and predicted yield and percent decrease for wheat sown at December, 11

Growth stage	Actual yield	Predicted yield	Percent decrease
End of tillering	**18.99**	**17.04**	**10.26**
End of booting	**18.99**	**16.45**	**13.35**
End of anthesis	**18.99**	**16.55**	**12.84**
End of grain fill	**18.99**	**17.17**	**8.58**

2.5. Prediction equations for wheat sown at December, 26

Results in Table (6) shown that the highest R^2 and the lowest SE% were observed for equation [12] followed by equation [9].

Table (6): Prediction equations for different growth stages for wheat sowing at December, 26

Growth stage	Prediction Equation	R^2	SE%
End of tillering	[9]Y^=33.29-0.51Mtemp*-0.04Rain-0.02SR**	0.857	10.6
End of booting	[10]Y^=39.17-0.53Mtemp*-0.041Rain-0.04SR**	0.821	11.7
End of anthesis	[11]Y^= 40.02-0.75Mtemp*-0.14Rain-0.02SR	0.809	12.4
End of grain fill	[12]Y^=49.18-0.195Mtemp*-0.5Rain**0.063SR**	0.878	9.77

2.6. Prediction of wheat yield sown at December, 26

Results in Table (7) showed that percent decrease between actual and predicted yield were between 10.91-11.55 %. Results in that table showed that the lowest percent decrease between predicted and actual wheat yield was obtained when wheat yield was predicted at the end of grain filling period (PD = 10.91). Moreover, end of tillering could be also used for early prediction of yield because of its relatively low PD % (11.01 %). Figure (3) shows line fit between predicted and actual wheat yield planted at December, 26.

Table (7): Actual and predicted yield and percent decrease for wheat sown at December, 11

Growth stage	Actual yield	Predicted yield	Percent decrease
End of tillering	18.99	16.89	11.01
End of booting	18.99	16.79	11.55
End of anthesis	18.99	16.84	11.28
End of grain fill	18.99	16.91	10.91

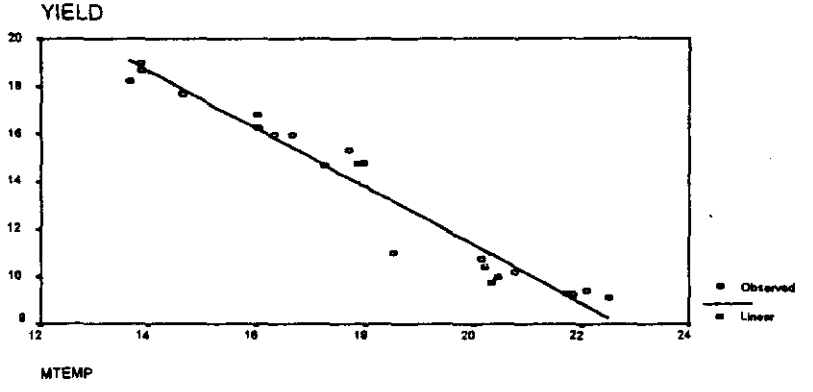

Figure (1): Grain yield as a function of temperature for wheat planted at November, 26.

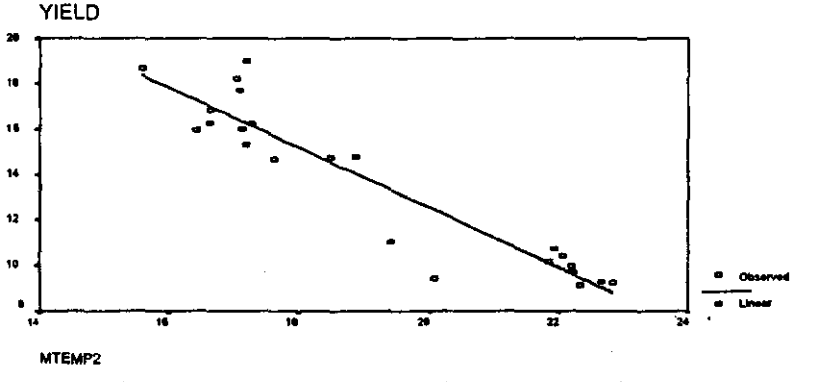

Figure (2): Grain yield as a function of temperature for wheat planted at December, 11.

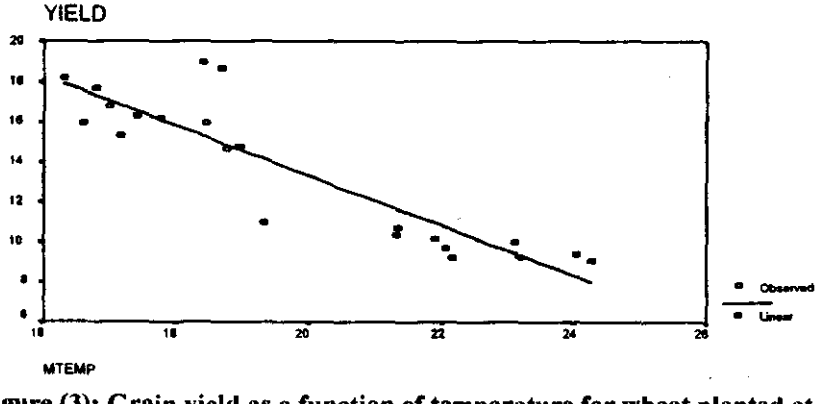

Figure (3): Grain yield as a function of temperature for wheat planted at December, 26.

3. Determinng of percent of yield reduction as a result of delay sowing

Percent decrease in yield as a result of delay sowing at Midlle Egypt region was also estimated using equations [4], [8], [12]. Percent decrease in yield as a result of delay sowing up to December, 11 was found to be 6.60 %, whereas the reduction was 7.98 % when sowing was delay until December, 26 (Table 8 and Figure 4).

Table (8): Predicted wheat yield under different sowing dates at MiddleEgypt Region

Sowing Date	Predicted Yield (Ardab/fed)	Percent Decrease %
November, 26	18.38	0
December,11	17.17	6.60
December,26	16.91	7.98

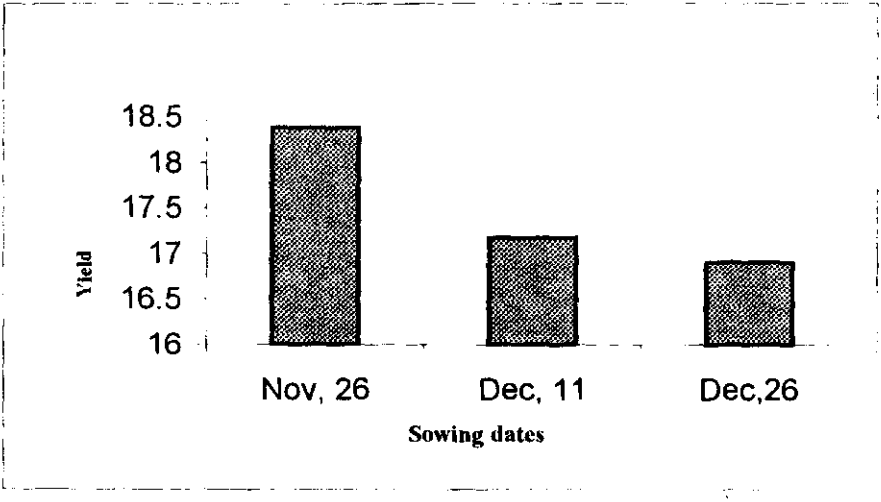

Figure (4): Predicted wheat yield at different sowing dates

4. Testing the validity of the developed equations

4.1. Predicting wheat yield for different cultivars

Actual yield of six wheat cultivars were compared to predicted yield presented at Table (8). Results in Table (9) showed that when wheat planted at November, 26, any of the six variaties could be suitable, except for Giza 168 (PD = 9.09 %). However, when sowing was delayed to December, 11, Gemmeiza 7, Sakha 69 and Sids 1, could be planted without large reduction in yield (PD = 5.34, 7.78 and 9.15 %, respectively). Similarly, when wheat sown delayed until December, 26, Gemmeiza 7, Sakha 69 still have relatively low PD (6.78 and 9.13 %, respectively).

Table (9): Predicated wheat yield under two types soil at Middle Egypt Region.

Sowing date Varieties	Actual yield	November, 26	December, 11	December, 26
		PD %		
Sakha 69	18.62	1.29	7.78	9.18
Sakha 93	19.35	5.01	11.25	12.60
Sids 1	18.90	2.75	9.15	10.52
Giza 168	20.22	9.09	15.08	16.36
Gemmeiza 7	18.14	1.32	5.34	6.78
Gemmeiza 9	19.85	7.40	13.5	14.81

4.2. Predicting wheat yield using previous year weather parameters

Equations [4], [8] and [12] were used to predict wheat yield of 2000/01, 2001/02 and 2002/03 seasons through using previous year weather parameters. Results in Table (10) showed that the lowest percent decrease (PD%) between actual and predicted wheat yield was obtained for growing season of 2001/02 when wheat was sown at November, 26 (0.12 %) followed by growing season of 2002/03 at the same sowing date (1.06 %) followed by growing season of 2000/01 at sam sowing date (1.71 %). Larger decreases in yield were observed as a result of delay sowing, which could be an indication that using pervious year weather parameters to predict the following year wheat yield could be more accurate if it was done for wheat sown at November, 26.

Table (10): Predicted wheat yield using pervious year weather parameters

Sowing date Season	Actual yield	November, 26		December, 11		December, 26	
		predicted	PD%	Predicted	PD%	Predicted	PD%
2000/01	18.60	18.28	1.71	17.02	8.27	16.46	11.48
2001/02	18.92	18.89	0.12	18.40	2.70	17.18	9.15
2002/03	19.08	18.87	1.06	17.65	7.45	16.43	13.84

REFERENCES

Bagga, A.K. and Rawson, H.M. (1977): Contracting responses of morphologically similar wheat cultivars to temperature appropriate to warm temperature climates with hot summers: A study in controlled environment. Aust. J. Agric. Res. 40:965-80.

Draper, N. R. and Smith, H. (1987):Applied Regression Analysis. John Wilay and Sons, Inc. New York. pp. 397 - 402.

Eid, H. M.; El-Marsafawy, S. M.; Ali, M.A.; Ainer, N.G.; Rayan, A. A. and El-Kholi, O. (1997): Vulnerability and adaptation to climate change in wheat crop. Meteorology and Environmental Cases. Conf. pp.152-165. March, 1997. Egypt.

Eid, H. M.; El-Marsafawy, S. M.; Tantawy, M.M. and Salib, A.Y. (1999): Prediction of optimum sowing dates for wheat in different regions in Egypt. 3rd Conference of On-Farm Irrigation and Agroclimatology.

El-Marsafawy, S.M., Ali, M.A; Salib, A.Y .and Eid, H.M. (1998): Effect of different sowing dates on some wheat varieties yield and their water relations. The 2nd conference for Meteorology and Sustainable Development. Feb. 1998.

Friend, D.J.C. (1965): Ear length and spikele number of wheat grown at different temperatures and light intensities. Cand. J. Bot. 43:343-353.

Gardner. F.P., Pearce, R.B, and Mitchell, R.L. (1985): Physiology of Crop Plants. Iowa State University Press. Ames.

McMaster, G.S. (1997): Phonology, development, and growth of wheat (Triticum aestivum L.) shoot apex: A review. Advaces in Agron. 59:63-118.

Moshref, M.K.H.; Mostafa, A. K. and Hamada, A.A. (2001): Identification of bread wheat cultivar suitable for El-Faayoum governorate conditions.Egypt. J. Agric. Res., 79(4)

Rayan, A.A., Samia M. El-Marsafawy and Mohamed, K.A. (1999): Response of some wheat varieties to different sowing dates and irrigation regimes in Upper Egypt. Third Conference of On-Farm Irrigation and Agroclimatology SWERI, ARC Egypt.

Sofield, I.; Evans. L. T. and Wardlaw, I. F. (1977): The effect of temperature and light on grain filling in wheat. R. Soc. N. Z. Bull. 12:909-915.

Swilam. S. M, Samiha A. Ouda and El- Tantawy, M. M. (2004): Predicting wheat yield at delta region under different sowing dates using historical weather data.

Wiegand, C. L.; and Cuellar, J. A. (1981): Duration of grain filling and kernel weight of wheat as affected by temperature. Crop Sci. 21: 95-101.

Wilhelm, W. W. and McMaster, G. S. (1995): The importance of phyllochron in studying the development of grasses. Crop Sci. 53:1-3.

استخدام بيانات الارصادالجوية للتنبؤ بمحصول القمح تحت مواعيد زراعه مختلفه فى منطقة مصر الوسطى

سامية جوده عطية محمد ، سهيرمحمد سويلم ، احمد مؤمن عبد العزيز

المعمل المركزى لبحوث التصميم والتحليل الاحصائي - مركز البحوث الزراعيه

يهدف هذا البحث الى عمل معادلات انحدار للتنبؤ بمحصول القمح باستخدام بيانات الارصاد الجوية فى منطقة مصر الوسطى تحت عدة مواعيد زراعة مختلفة بالاضافة الي اختبار هذه المعادلات للتنبؤ بمحصول القمح تحت الظروف المختلفة. وتم جمع متوسط درجات الحرارة والاشعاع الشمسي والمطر فى محافظة الفيوم والجيزة كممثل لمنطقة مصر الوسطى في الفترة من١٩٧٧الى ٢٠٠٣ وايضا تم جمع بيانات لانتاجية القمح في تلك المنطقة للفترة السابقة.تم عمل التحليل الاحصائى للتنبؤ بمحصول القمح تحت عدة مواعيد زراعة مختلفة وهى(٢٦ نوفمبر و ١١ديسمبر و٢٦ ديسمبر) وايضا تحت اربعة مراحل فينولوجية مختلفة، الاولى من الزراعة حتى نهاية تكوين الاشطاء والثانية من الزراعة حتى بداية تكوين الحبوب والثالثة من الزراعة حتى نهاية التزهير والرابعة من الزراعة حتى نهاية امتلاء الحبوب واستخدمت بيانات الارصاد في الفترة من ١٩٧٧ الي ١٩٩٩ لعمل معادلات للتنبؤ في كل مرحلة

نموولكل موعد زراعة٠ وتم أستخدام هذه المعادلات مع بيانات أرصاد موسم نمو ١٩٩٩/٢٠٠٠ للتنبؤ بالمحصول في هذه السنة ، ثم تم مقارنته بالمحصول الفعلي لنفس السنه وحساب النقص بين المحصول الفعلي والمتنبأ به٠ بالاضافة الىذلك تم أستخدام المعادلات في التنبؤ لمحصول القمح لسنة ٢٠٠١ بأستخدام بيانات ألارصاد الجوية لموسم نمو١٩٩٩/٢٠٠٠ والتنبؤ بمحصول القمح لسنة ٢٠٠٢ بأستخدام بيانات الارصاد الجوية لموسم نمو٢٠٠٠/٢٠٠١وكذلك والتنبؤ بمحصول القمح لسنة٢٠٠٣ بأستخدام بيانات الارصاد الجوية لموسم ٢٠٠١/٢٠٠٢ وتم مقارنة ذلك بالمحصول الفعلي وحساب نسبة النقص بين المحصول الفعلي والمتنبأ به ٠ بالاضافة الي عمل أختبار لمعادلات التنبؤ بأستخدام تجربة اقيمت في منطقة الفيوم في موسميين ١٩٩٨/ ١٩٩٩ ، ١٩٩٩/٢٠٠٠ لستة اصناف من القمح سخا ٦٩ ، سدس ١ ، سخا ٩٣ ، وجيزة ١٦٨ ، جميزه ٧ ، وجميزة ٩ وقد اوضحت النتائج ان اعلي نسبة للتنبؤ بالمحصول كان فى مرحلة أمتلاء الحبوب بالنسبة لمواعيد الزراعة الثلاثة علاوة علي انه كان اقل نسبة للنقص في التنبؤ بالمحصول فى مرحلة تكوين الاشطاء ايضا للثلاث مواعيد زراعة٠ وكان نسبة النقص بين المحصول الفعلي والمتنبأ به هو ٦,٦٠% عند زراعة القمح في ١١ ديسمبر بينما كان عند زراعة القمح في ٢٦ ديسمبر كانت نسبة النقص ٧,٩٨% . بينما في حالة التجربة المنزرعة في منطقة الفيوم وجد أن عند زراعة القمح في ٢٦ نوفمبر كانت جميع الاصناف أكثر ثباتا ماعدا الصنف جيزة ١٦٨ وكان اعلي نسبة للنقص في المحصول الفعلي والمتنبأ به ٩,٠٩% ٠ وايضا تشير النتائج ان أقل نسبة للنقص في المحصول للصنفيين جيزة ٧ ، وسخا ٦٩ (٧٨و٦ %–١٨و٩ %)علي التوالي في حالة تأخير الزراعة الي ٢٦ ديسمبر ٠بينما تشير النتائج الي انه في حالة الزراعة في ٢٦ نوفمبر كانت أقل نسبة للنقص لمحصول القمح بين المحصول الفعلي والمتنبأ به لموسم ٢٠٠١/٢٠٠٢ (١٢و%) تليها محصول موسم ٢٠٠٢/٢٠٠٣ (١,٠٦ %) ثم موسم ٢٠٠٠/٢٠٠١ (١,٧١ %) ٠وبناء علي هذه النتائج انه في حالة تأخير الزراعة الي ١١ ديسمبر يوصي بزراعة أصناف جميزة ٧ ، سخا ٦٩ اوسدس١ وعند تأخير الزراعة الي ٢٦ ديسمبر يوصي بزراعة صنف جميزة ٧ اوسخا ٦٩.