Al-Muthanna J. For Agric Sci Print ISSN: 2226-4086 Online ISSN:2572-5149
Vol. 9 , Issue. 02. 2022

https://muthjas.mu.edu.iq/ http://doi.org/10.52113/mjas04/9.2/26

Effect of planting distance on the production of full of and long grains with addition of NPK and organic acids characters and dates on yield sunflower (*Helianthus annuus* L.)

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Received on 2/10/2022 Accepted on 30/10/2022 Published on 15/12/2022

Abstract

A field experiment was conducted during the spring season 2021 in agriculture field in Al-Rumaitha district, which was 25 km from the center of Al-Muthanna Governorate, to study the effect of plant distance and different fertilizer combinations on the purchasing value and the size of sunflower grains (Shumoos). A factorial experiment was carried out by using the split plot Experiment, according to a randomized complete block design R.C.B.D with three replicates. The experiment included the two factors , the first factor was four plant distance : (55, 45, 35 and 25) cm, and the second was four different fertilizer combinations of N.P.K and organic acids: (100%, 1/4, 1/2 and 3/4) kg ha^{-1}. The grains were sown on 03-15-2021 with different distances between plant and 75 cm between one line and another. The plant wide spacing between sunflower plants significantly affected most of the yield traits; the distance of 55 cm was superior in the highest mean disc diameter, number of filled grains, weight of 1000 gm and harvest index, while the sowing distance distance of 25 cm was significantly superior in giving the highest mean of total grain yield. The addition of different fertilizer combinations affected all vegetative growth characteristics, fertilizer level exceeded F2 (120 kg N ha^{-1},75 kg P_2O_5 ha^{-1},120 kg K_2O ha^{-1} +30 kg ha^{-1} humic and fulvic) on disc diameter, number of filled grains, weight of 1000 grains, harvest index and total grain yield. The effect of the interaction between the two factors of the study was significant on most of the studied traits. the treatment F2D4 significantly

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superiority, by giving it the highest average for each of the disc diameter, the number of filled grains, weight of 1000 grains, and the harvest index, whereas, the combination F2D1 gave the highest Mean for the total grain yield

Key words: plant spacing, fertilizer combinations, yield traits, sunflower (*Helianthus annuus* L.)

Introduction

Sunflower one of the most important and strategic oil grain crops of the compound family Asteraceae, worldwide adaptation, it's cultivation succeeds in different environmental and climatic conditions (Al-Jayashi, 2014).

The sunflower crop is characterized by its dual-purpose varieties, either oily or non-oily; its oil varieties are raw material for most industries, such as the manufacture of vegetable butter, bread products, biscuits, soap and dyes, and other industries (Al-Badri, 2013). As for its non-oily mean , its importance and consumption are concentrated in human nutrition, as it is palatable, has a high nutritional value, and has a distance flavour after roasting (Al-Rawi et al., 2013). Each 46 grams of dry sunflower grains contains 370 calories, . (Nandha, 2014) Anjum et al, 2010) of the crop is also used as Forage because it contains 30-30% protein and carbohydrates, while the stalks can be used (Al-Baldawi, 2014).

Determining the plant spacing between plants is one of the most critical agricultural processes that significantly impact competition between plants and its relationship to plant growth and the depletion of nutrients from the soil, in addition, it affects the penetrating light and heat available to plants and their direct impact on the completion of the process of carbon metabolism and its reflection on most physiological processes Which contribute to increasing grain production (Al-Hasawi, 2014). The results of Day et al. (2016) showed that planting sunflower at a distance of 30 cm between the plants was significantly superior to the highest mean weight of 1000 seeds of 119.5 g compared to Sowing at a distance of 20 cm between the grooves, which gave the lowest mean of the trait amounted to 110.8 g. The researcher himself did not find a significant difference between distances Farming among the harvest in the harvest guide.

This study aims to determine the best distance between plants to get full and large grains, and determining the best fertilizer combinations of N.P.K. fertilizer and organic acids (humic and fulvic) affecting in increasing the size and number of grains per disc. Al-Waeli (2018) indicated that the addition of 25% of the fertilizer recommendation for nitrogen, phosphorous and potassium was significantly superior to the highest average number of seeds 1050.5 disc^{-1}, the individual plant yield 78.59 g plant^{-1}, and the harvest index for sunflower 40.35% compared to the comparison treatment that gave the lowest averages of 744.3 disc seed $^{-1}$, 55.23 gm of plant $^{-1}$, 32.30% for the aforementioned traits sequentially.

Material and methods

Experiment site

A field experiment was conducted in Al-Rumaitha district (25 km north of Al-Muthanna governorate center) on the land

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belonging to a farmer during the spring season of 2021 to determine the effect of plant spacing and different fertilizer combinations on the purchasing value and the size of sunflower grains.

Study Factors:

The experiment involved studying two factors:

The first factor: four planting distance between plants and symbolized by the letter D, were: D1: 25 cm/plant density 53.333 plants ha^{-1}, D2: 35 cm/plant density 38.095 plants ha^{-1}, D3: 45 cm / plant density 29.629 plants ha^{-1}, D4: 55 cm / plant density 24.242 plants ha^{-1}.

The second factor: Four fertilizer combinations of N.P.K and organic acids (humic and fulvic) and symbolized by the letter F, namely: 1/4 Fertilizer Recommendation: F1(40 kg N ha^{-1},25 kg P_2O_5 ha^{-1},40 kg K_2OH^{-1})+ 30 kg ha^{-1} humic and fulvic. 1/2 Fertilizer Recommendation: F2 (80 kg N ha^{-1}, 50 kg P205 ha^{-1}, 80kg K2O ha^{-1}) + 30 ha^{-1} humic and Fulvic. 3/4 Fertilizer Recommendation: F3(120 kg N ha^{-1}, 75 kg P_2O_5 ha^{-1}, 120 kg K_2O H^{-1})+ 30 kg ha^{-1} humic and fulvic. 100% Fertilizer Recommendation: F4 (160 kg N ha^{-1}, 100 kg P2O5 ha^{-1}, 160 kg K_2O ha^{-1}).

Design of the experiment:

The experiment was conducted according to the design of factorial trials within a split-polt using the randomized complete block design (R.C.B.D) with three replicates. The experiment included 48 experimental units all the combinations between the studied factors and their frequencies. The different fertilizer combinations Arranged in main plots and the agricultural distances represented the secondary plots (Sub Plot) was in sub -plot

Soil analysis:

after removing plant residues. Samples were taken from the field soil before planting and from different locations of the ground at a depth of 0-30 cm The soil was pneumatically dried, crushed, and sieved into a sieve with holes 2 mm in diameter and mixed well to homogenize it, representative samples were taken, and perform physical and chemical analyzes (table 1).

Planting procedure:

After selecting the appropriate land for the experiment, conducting physical and chemical analyses of the field soil, the experimental land was plowed perpendicularly using the inverted correct it ;it was smoothed and smoothed. The field was divided into three blocks, and each block was divided into 16 experimental units, the area of each experimental unit was 12 m² (4 * 3 m), included 4 lines, the length of the lines was 4 m, and the distance between one line and another was 75 cm, given irrigation and left until the appropriate drought to carry out the cultivation process, Shumoos cultivar grains were sown on 15/3/2021 at a depth of 3 cm, by three grains per hole (Al-Sahoki, 1994). At the upper third of the line, the thinning process was carried out after the emergence of grains and the formation of the first pair of true leaves; one grains was left in each hole, and the field was irrigated by 8 irrigations, distributed over the growing season. Weeding was also carried out as needed. Use urea fertilizer (46% N) as a source of nitrogen, triple Super Phosphate (P_2O_5) 46% as a source of phosphorous, Potassium sulfate 50% (K_2O) as a source of potassium, with a fertilizer recommendation of 160 kg (N ha^{-1}), 100 kg (P2O5 ha^{-1}) and 160 kg (K2O ha^{-1}) (Al-

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Abedy, 2011). The plant was harvested on 23-06-2021 when signs of full maturity appeared the back of the tablets turned yellow, and the beginning of the coloration of the outer rings in brown.

Traits studied

The data on growth characteristics were taken as an average of ten plants taken randomly from the experimental units and from the two average numbers at the 50% flowering stage to determine of Disc diameter (cm), The number of full grains (grain disc), Weight of 1000 grains (gm), Total grain yield (tons) and Harvest Index (%):

In this section you should have multiple paragraphs describing different things. The first paragraph, for instance, describes the experimental site, season, and all relevant work in the field, glasshouse, greenhouse, etc. treatments and practical design in this section with all crop and soil management. If you have a graph or Table for the experimental site and environments such as soil properties, you should add it below this paragraph in the middle of the page.

Statistical analysis:

The data was analysed for the studied traits, according to the used design and using the statistical program Genstat. The mean differences were tested using the least significant difference (L.s.D.) at the level of significance (0.05) (Al-Rawi and Khalaf Allah, 1980).

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Table (1): Physical and chemical properties of soil before planting

Parameters	**Unit**	**Value**
ECe	dS . m-1	3.70
pH	-	7.10
Available nitrogen	mg kg^{-1} soil	27.50
Available phosphorous		13.50
Available potassium		138.00
Organic matter	g kg^{-1} soil	11.00
Soil properties		
Sand	g kg^{-1} soil	235.00
Clay		470.00
Silt		295.00
Soil texture	Silty clay loam	

The analyzes were carried out in the Soil Physics Laboratory, Agriculture College, Al-Muthanna University.

Results and Discussion

Disc diameter (cm):

The analysis of the variance table and the results of Table (2) indicate significant differences between plant spacing and fertilizer combinations and the interaction between them in the diameter of the disc. The plant spacing D4 was significantly superior by giving it the highest average disc diameter, was 29.17 cm with a significant difference from the distances D2 and D3, which were given an average of 25.94 cm and 27.69 cm respectively, compare with the plant spacing D1, which gave the lowest average for the trait, it was 22.96 cm. The reason for the superiority in disc diameter may be attributed to the lack of competition between plants of a wide distance due to the small number of plants per unit area, contributed to providing an adequate space to receive adequate light

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for plant growth requirements, which in turn stimulates the process of making food and increasing nutrients, and then increasing the number of leaves in the plant and the leaf area, contributed to raising the efficiency of the carbon metabolism process and increasing its metabolic products, which resulted in an increase in the diameter of the stem and an increase in the transfer of materials represented to the flowering inflorescence and then an increase in the diameter of the disc, in narrow spaces and due to the increase in the number of plants per unit area, this led to a lack of nutrients reaching the disc due to the lack of production in the leaves due to the increased competition for the different growth factors, which negatively affected the diameter of the formed disc, this result is in agreement with the findings of Al-Hasawi (2014) and Khamjan (2019).

From the same Table, it is clear that there are significant differences in the different fertilizer combinations added, as the fertilizer combination F2 gave the highest average disc diameter of 30.85 cm compared to the fertilizer combination F4, which gave the lowest average of 22.62 cm, the reason for this may be due to the increase in the levels of the added fertilizer F2, which affected the increase in the availability of nutrients, which was positively reflected in the increase in plant growth by increasing the root system, which in turn led to adequate transfer and absorption of nutrients to the upper parts of the plant, leading to an increase in growth indicators, including the formation and number of leaves, high leaf area and stem diameter, reflected positively on the increase in the diameter of the disc. This result is in agrees with the findings of (Al-Mughair, 2019).

As for the effect of the interaction between the two factors of the study, the results of the same Table indicate a significant impacts on the diameter of the disc. The F2D4 treatment achieved the highest value of the interference, which amounted to 34.50 cm, superior to that of the F4D1 treatment, which gave the lowest value of the interference, which was 20.39 cm, it was possible to trace the reason for the superiority of the interaction above treatment to the reasons mentioned when discussing the results of the factors when they are single, as there was a state of symmetry between the effects of the factors when they were single and when they interaction with each other.

Table (2) Effect of plant spacing and fertilizer combinations and the interaction on disc diameter (cm).

Plant spacing(D)	**Fertilizer combinations (F)**				**Means**
	F1	**F2**	**F3**	**F4**	
D1	22.78	25.47	23.21	20.39	22.96
D2	24.78	30.93	26.39	21.66	25.94
D3	26.28	32.51	28.37	23.61	27.69
D4	27.88	34.50	29.50	24.80	29.17
Means	25.43	30.85	26.87	22.62	
$L.s.d_{0.05}$	**D**		**F**		**D×F**

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	0.80	0.55	1.16

The Number of full grains (disc grain^{-1}):
Table (3) show that there were significant differences between plant spacing and different fertilizer combinations, and the interaction between them in the characteristic of the number of filled grains.

The distance D4 was significantly superior by giving it the highest mean number of filled grains, which amounted to 1283.4 disk-1 grains, with a significant difference from the distances D3 and D2, which gave the mean of 1199.3 and 1056.0 disk^{-1} grains, in comparison the distance D1 gave the lowest mean of the character reached 814.4 disk-1 grains. The reason is due to the lack of competition between plants for the available growth factors, especially the light in the stage of flower formation, which led to an increase in the manufacture of carbonic products, which led to an increase in growth indicators, which was positively reflected in the increase in the number of leaves and leaf area, as this effectively contributed to an increase in the products of The carbon metabolism process, which was reflected in the processing of emerging grains with their requirements of the factory lunch necessary for their permanence, which was positively reflected in the increase in the number of filled grains.

From the same Table, the addition of different fertilizer combinations significantly affected the number of grains in the disc, as the fertilizer combination F2 gave the highest average for the trait amounting to 1056.7 grain disc-1 compared to the fertilizer combination F4, which gave the lowest average of the trait amounted to 781.8 grain disc-1, the reason for the increase may be due to the increase In the number of filled grains to the role of the added fertilizer combination, which worked to provide the plant's need of significants elements (N, P, K) in the different stages of plant growth, which increased the efficiency of their absorption and transmission and its reflection on growth characteristics, increased number of leaves and leaf area and increased diameter The disc, which in turn led to an increase in the number of grains filled in the disc.

It was noted that there is a significant interaction between the two factors of the study, as the two treatments F2D4 and F2D3 excelled in giving the highest mean of 1673.9 grains of disk^{-1} and 1547.4 grains of disk^{-1} respectively, compared to treatment F4D1, which recorded the lowest average of 626.6 grains of disk$^{-1.}$ mentioned in the discussion of singular factors.

Table (3) Effect of plant spacing and fertilizer combinations and the interaction between them on the number of filled grains (disc-1 grain)

Plant spacing (D)	Fertilizer combinations (F)				Means
	F1	**F2**	**F3**	**F4**	
D1	802.5	986.7	841.6	626.6	814.4
D2	1053.2	1409.3	1082.4	679.0	1056.0
D3	1172.6	1547.4	1226.6	850.1	1199.3
D4	1198.6	1673.9	1289.4	971.6	1283.4

https://muthjas.mu.edu.iq/ http://doi.org/10.52113/mjas04/9.2/26

Means	1056.7	1404.3	1110.0	781.8	
l.S.D$_{0.05}$	**D**		**F**		**D×F**
	36.98		43.87		73.25

Weight of 1000 grains (gm)

The results showed that there were significant differences between plant spacing and different fertilizer combinations, The interaction between the two study factors in the weight of 1000 grains, the increase in the agricultural distances between plants led to a significant increase in the weight of 1000 grains, as the plant spacingD4 gave the highest average for the trait, which amounted to 84.61 gm, while the distance D3 gave an average of 78.04 g, with a significant difference from the distance D2, which gave an average of 68.40 gm compared to the distance D1 which recorded the lowest. average 52.12 gm, the reason for the increase in the weight of 1000 grains in wide agricultural distances may be attributed to the amount of food that is prepared for it from the source, in addition to the downstream and its ability to withdraw the most significant amount of metabolites, in addition to the increase in the rates of carbonation resulting from the increase in what one plant obtains of nutrients due to the lack of competition between plants, which created an opportunity for the plant by better exploiting the different grow++th factors, which was reflected in the increase in the leaf area of one plant, this result was consistent with the findings of Demir (2020).

As for the different fertilizer combinations in the same Table, the results also significantly affected the weight of 1000 grains, as the fertilizer combination F2 achieved the highest average of 96.38 g, compared to the fertilizer combination F4, which gave the lowest average of 48.01 gm. The reason for the increase in the weight of 1000 grains may be attributed to the addition of 75% of the fertilizer recommendation for nitrogen, phosphorous and potassium with the addition of humic acids, it Which has contributed to stimulating plant growth and increasing its physiological effectiveness, which led to an increase in the accumulation of dry matter and its transfer to the storage organs of the plant (grains), which reflected positively on the increase in grain weight, these results are in agreement with the findings (Al-Mughair, 2019).

The results also indicate a significant interaction between the two factors of the study, as treatment F3D4 achieved the highest mean for the trait amounting to 115.40 g compared to treatment F4D1, which gave the lowest mean for the trait amounted to 41.27 g, lt did not differ significantly from treatments F1D1 and F4D2 which gave 42.67 and 44.58 g, respectively, and that it was significant. The interaction was due to the magnitude of the response of the trait to the fertilizer combinations when the planting distance between plants changes.

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Table (4) The effect of plant spacing and fertilizer combinations and the interaction between them on the weight of 1000 (gm)

Plant spacing (D)	**Fertilizer combinations (F)**				**Means**
	F1	**F2**	**F3**	**F4**	
D1	42.67	76.46	48.07	41.27	52.12
D2	66.17	93.42	69.45	44.58	68.40
D3	76.50	100.23	84.42	51.03	78.04
D4	81.48	115.40	86.42	55.16	84.61
Means	66.70	96.38	72.09	48.01	
l.S.D$_{0.05}$	**D**		**F**		**D×F**
	3.98		1.77		4.64

Total grain yield (ton ha^{-1}):

The results of the analysis of variance analysis results show significant different fertilizer combinations, and the interaction between the two study factors in the total grain yield.

The results of Table (5) indicate the superiority of the narrow planting distance D1 with high plant density in giving the highest average of the total grain yield, which reached 5.28 tons ha^{-1}, superior to the two agricultural distances with low plant density represented by the agricultural distances D2 and D3, which were given averages of 4.67 tons ha^{-1} and 4.16 T ha^{-1} respectively, compared to the D4 distance, which recorded a significant decrease in the average for this trait of 3.78 T ha-1. The reason for the increase in the total grain yield in narrow spaces may be attributed to the increase in the number of plants per unit area, which compensated for the decrease in the components of the yield represented by the number of grains per disc, the weight of 1000 grains and the yield of the individual plant, which reflected on the increase in the total grain yield, as for the decrease in the wide distances despite the increase in the yield of the individual plant, the number of grains per disk, and the weight of 1000 grains, but it could not compensate for the decrease in the number of plants per unit area. This result agreed with the findings of Ahmed (2012).

It is also noted from the same table that the moral superiority of the fertilizer mixture F2 in giving it the highest average of 6.01 tons ha^{-1} compared to the fertilizer mixture F4, which recorded the lowest average of 3.32 tons ha^{-1}, the reason for the increase may be due to the superiority of the fertilizer mixture itself in the diameter of the disc, the number of grains in the disc, the weight of 1000 and the yield of the individual plant, and by its effect, the grain yield increased, and this is consistent with what was reached by Al-Mughair (2019), whose results indicated a significant increase in the total grain yield when adding N.P.K. and humic acids to sunflower.

As for the effect of the interaction between plant spacing and different fertilizer combinations on the total grain yield, same Table's results indicated that there were significant differences between the two factors of the study. Treatment F4D4 achieved the lowest interference value of 2.65 tons ha-1. It is possible to attribute the reason for the superiority of the

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interventions to the reasons mentioned when discussing the results of the factors alone.

Table (5) Effect of planting distances and fertilizer combinations and the interaction between them on the total grain yield (ton ha-1)					
Plant spacing (D)	**Fertilizer combinations (F)**				**Means**
	F1	**F2**	**F3**	**F4**	
D1	4.97	6.78	5.07	4.31	5.28
D2	4.53	6.19	4.62	3.36	4.67
D3	3.98	5.61	4.10	2.94	4.16
D4	3.43	5.46	3.60	2.65	3.78
Means	4.22	6.01	4.35	3.32	
l.S.D$_{0.05}$	**D**		**F**		**D×F**
	0.12		0.10		0.20

Harvest Index (%)

The results of the analysis of variance showed that there were significant differences between planting distances and different fertilizer combinations, and the interaction between them in the trait of harvest index.

The results of Table (6) indicated that the planting distance D4 was superior in giving the highest mean of the harvest index, which amounted to 37.94% without a significant difference from the agricultural distance D3, which gave an average of 37.36%, and with a significant difference from the agricultural distance D2 which showed an average of 34.50% compared to the agricultural distance D1 which gave an average of 34.50%. It gave the lowest average for the trait, which was 31.70%. The reason for the increase in the harvest index when increasing the planting distance between plants may be due to the lack of competition between plants of the wide distance for production elements, which made the plants grow in better conditions and thus provide higher food storage, which was reflected on the increase in the transformational efficiency of the plant from the source to the estuary under the conditions of increasing the individual grain yield, which was positively reflected on the value of the harvest index. This result agreed with what was found (Abdullah, 2008).

The results of the same Table also indicate that there are significant differences between the fertilizer combinations in the harvest index, as the fertilizer combination F2 outperformed in giving the highest average for the trait amounting to 39.87% compared to the fertilizer combination F4, which gave the lowest average of 31.58%.

The reason for the superiority may be due to the increase in the vegetative growth indicators of the plants of this combination, which was positively reflected in the increase in the efficiency of these plants in redistributing nutrients from the source to the downstream (the grain), meaning that these plants have a better effect in stimulating the source to increase the ability of the grains to absorb the increase obtained in dry matter, which was reflected on the increase in the number of grains and the yield of the individual plant and thus reflected on the increase in the

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harvest index. This result is consistent with what was reached (Al-Mughair, 2019).
The results of the same Table also show that there is a significant interaction between the two factors of the study, as the two treatments F2D4 and F2D3 outperformed in giving the highest value of the interference amounted to 43.75% and 42.66% compared to the treatment F4D1, which gave the lowest value of the interference amounted to 28.74%, the reason for this may be attributed to what was mentioned in the discussion The factors are singular.

Table (6) Effect of planting distances and fertilizer combinations and the interaction between them on the harvest index (%)

Plant spacing (D)	Fertilizer combinations (F)				Means
	F1	**F2**	**F3**	**F4**	
D1	31.08	34.91	32.08	28.74	31.70
D2	34.64	38.19	34.36	30.82	34.50
D3	36.94	42.66	36.83	33.02	37.36
D4	37.32	43.75	36.95	33.73	37.94
Means	34.99	39.87	35.06	31.58	
l.S.D$_{0.05}$	**D**		**F**		**D×F**
	1.03		0.52		1.27

Conclusion

It is concluded that the wide agricultural distance between sunflower plants has a significant effect on most of the yield traits and that the addition of F2 fertilizer combinations gave the best results, and that the F2D4 interaction had a significant impact by giving it the highest average of the studied traits.

Acknowledgement

We thank the Deanship of the College of Agriculture at Al-Muthanna University for facilitating the requirements of this research, as well as extending our thanks to the workers in the laboratories of the College of Agriculture for their assistance in conducting the examinations for this study.

https://muthjas.mu.edu.iq/ http://doi.org/10.52113/mjas04/9.2/26

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Al-Muthanna J. For Agric Sci Print ISSN: 2226-4086 Online ISSN:2572-5149
Vol. 9 , Issue. 02. 2022

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Yield of Two Varieties of Sunflower(Helianthus annuus L.).A thesis Submitted to In Partial Fulfillment of the Requirements for the Degree of M.Sc. in Agriculture (Agronomy).

Nandha, R., H. Singh, Kamlesh. G, Seema. R. (2014). Therapeutic potenttial of sunflower grain. International Journal of Research and Development in Pharmacy and Life Sciences, Vol. 3, No.3, pp 967-972.