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Comparative Study between the Performances of Nile Tilapia Oreochromisniloticus during and Out of the Normal Spawning Season

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Abstract: *During the production season (2010-2011), this work was carried out at a commercial tilapia hatchery in Motobas, Kafr El-Sheikh Governorate- Egypt. Two experiments were managed using the same design to make a comparison between spawning of Nile tilapia Oreochromisniloticusbroodstock off-season (the winter) and on-season (the summer). The two experiments were tested by studying the effects of using feed additive (Nuvisol hatch P® 0.1%), different broodstock sizes (350, 200, 150 and mixed up to 250 g/fish) and stocking densities (50, 55, 60 female/pond-24m²) on growth performance, feed utilization, reproductive performance and economical profitability parameters of Nile tilapia, O. niloticus spawned in the summer and in the winter. Comparing the results of the economic analysis of the two experiments showed that the total production of Nile tilapia fry per each spawning pond, 24 square meters, is 28,090 within the natural spawning season, an increase of 2.23% from that was spawning outside the normal season (27478 fry). Though total revenue and net income under hatchery conditions in the out off-season (February 2010) much higher than that in natural spawning season (April 2011) by 22.01%***.** *This is of course due to the price of tilapia fry in the winter months is higher than the summer to supply shortages in winter and increased demand at the same time. This is due to the farmers need to start the growing season early, March/April, in order to harvest their fish before temperatures drop in the next winter, which adversely affect the life of the fish.*

Introduction

Tilapia is a good fish for warm-water aquaculture. They are easily spawned, use a wide variety of natural foods as well as formulated feeds, tolerate poor water quality, and grow rapidly at warm temperatures. Nile tilapia,(*Oreochromisniloticus*), is currently considered to be the most important and commonly cultured tilapia species all over the world and constitutes over 70% of the cultured tilapia (Fitzsimmons, 2004). In general, low broodstock densities gave better seed production than higher densities (Bautista *et al*., 1988). Poor broodstock productivity, owing to low fecundity and asynchronous spawning cycles, remains one of the most significant outstanding constraints upon commercial tilapia production and its future expansion. Broodstock density is one of the important biological factors that have considerable influence seed production in tilapia (Obi and Shelton 1988). In ponds, the low production of tilapia fry has been attributed to a suboptimal broodstock density (Mires , 1982). On the other hand, under intensive hatchery systems, broodstock are often stocked at high densities in small breeding units such as aquaria, tanks and net enclosures (hapas), resulting in aggression and getting between males, and thus, affecting seed production. The manipulation of broodstock density is one of several techniques applied to improve mass production of tilapia seeds (Abella and Batao 1989). Therefore the main objectives of the present work were to make a comparison between spawning of Nile tilapia *Oreochromisniloticus*broodstock off-season (the winter) and on-season (the summer), which tested by studying the effects of using feed additive (Nuvisol hatch P® 0.1%), different broodstock sizes (350, 200, 150 and mixed up to 250 g/fish) and stocking densities (50, 55, 60 female/pond-24m²) on growth performance, feed utilization, reproductive performance and economical profitability parameters of Nile tilapia, *O. niloticus* spawned in the summer and in the winter.

Materials and methods

During the production season (2010-2011), this work was carried out at a commercial tilapia hatchery in Motobas, Kafr El-Sheikh Governorate- Egypt. The experimental fish were obtained from a private fish farm in Kafr El-Sheikh Governorate, Egypt. Two experiments were managed using the same design. The first experiment was carried out during january and february 2010-2011,in order to study the effect of feed additives, different broodstock sizes and stocking density on growth performance, feed utilization, reproductive performance and economical profitability parameters of Nile tilapia, *O. niloticus*, spawned off-season by controlling environmental conditions and under different management conditions. For doing so, 4032 of Nile tilapia (*O. niloticus*) broodstock were netted from earthen ponds, selected manually, sexed and transferred to conditioning concrete tanks, where held and kept separately for 20 days for adaptation to the new environment until starting the experiment. During winter season (Off season)Special tanks containing heaters were used to reach the optimum temperature for hatching. Forty eight concrete tanks (3×8×1 m) were used in the 1st experment, four different weights (350, 200, 150 and mixed up to 250 g/fish) of broodstock were combined with three different stocking densities (50, 55, 60 female/pond) and divided into two groups, the first one was fed on treated diet with Nuvisol hatch P®, and the second group was fed on the same diet but without adding Nuvisol hatch P® (Table 1), to obtain 24 duplicated experimental treatments.Sex ratio of Broodstock fish (1 male: 2.5 female). The feeding rate was 3% of the live biomass for the first 15 days, and then it has been reduced to 1.5% for the rest time, because the broodstock in this period have brood the eggs till hatching. Water exchanging rates have been varied according to the temperature outside the greenhouse. This experiment lasted for 28 days. On the other hand, the second experiment was carries out duringApril and May 2010 (on-season).The same design of the previous experiment was carried out but without using the heater. Feeding rates, water exchanging rates, weights of the experimental fish, and the stocking densities were the same as in the first experiment.

Table (1): The composition and chemical analysis of the experimental diets (%on dry matter basis) for the first experiment.

Ingredients composition	**Control %**	**Diet No.1 %**
Fish meal 72%	10	10
Soybean meal 44%	38	38
Yellow corn	30	30
Wheat bran	16	16
Sun flower oil	3	3
Premix *	3	3
****Nuvisol hatch P®**	0	0.1
Chemical analysis (%)		
Dry matter (DM)	91.8	92.15
Crude protein (CP)	26.02	26.25
Ether extract (EE)	9.65	9.81
Ash	8.12	7.32
Crude fiber (CF)	6.21	6.64
Nitrogen free extract (NFE)	50.00	49.98
Gross energy (GE)*(kcal/100gDM)**	444.21	446.93
Protein/energy ratio(P/E)** (mg CP/kcal GE)**	58.58	58.73

*Premix Composition:- Each 3 kg contains
Vit. A 1200000 i.u., Vit. D 300000 i.u., Vit. E 700 mg, Vit. K3 500 mg, Vit. B1 500 mg, Vit. B2 200mg, Vit. B6 600mg, Vit. B12 3mg, Vit. C 450mg, Niacin 3000mg, Methionine 3000mg, Cholin chloride 10000mg, Folic acid 300mg, Biotin 6mg, Panthonic acid 670mg, Magnesiam salphate 3000mg, Copper sulphate 3000mg, Iron sulphate 10000mg, Zinc sulphate, 1800mg, Cobalt sulphate 300mg, Carrier upto 3000mg.

** Nuvisol Hatch P®, Each 1 Kg contains the following vitamins (in mg): B1 4000, B2 5000, B3 4000, B6 2000, B9 1000, B12 20, PP 10000, Biotin 50, and L–carnitine 30000.
*** GE (Gross energy) (kcal / 100 g DM) = CP × 5.64 + EE × 9.44 + NFE × 4.11 calculated according to Macdonald et al.,(1973)
**** Protein/energy(P/E) ratio = crude protein × 10000 / Digestible energy according to Garling and Wilson, (1976).

Results and Discussion
The First Experiment

Effect of Feed additives, body size and stocking densityon growth performance and survival rates

The results of the present study proved that the addition of feed additive (**Nuvisol hatch P®**) has increased the rates of growth in tilapia broodstock especially males, which far outperformed females (Tables 2).Sharawi (2010) concluded that dietary inclusion of 1 g Nuvisol Hatch P®/Kg diet and 1 g Therigon®/Kg diet before Nile tilapia mating realized a good female's reproductive performance. The present results showed that Nile tilapia broodstock achieved 100% survival rate in all the circumstances of the first experiment (Table 2). Similar results were obtained by Tahoun (2007).

From (Table 2) also it can noted that there is a positive impact of the size of the broodstock on growth performance parameters, especially in males, where the differences were significant ($P<0.05$), while in case of females were minor. Generally, growth rates of males have far outperformed females (Toguyeni*et al.*, 2002). Large male tilapia achieved much higher growth rates than medium and small sizes by 51.5%, in large females the supremacy of the small and medium-sized weights by 18.6%.While in the case of mixed sizes, they overtook the male tilapia small size only, while in the case of females outperformed the small size of tilapia by 60.90% and medium size by 21.9%. Tahoun (2007) stated that, growth performance of Nile tilapia broodstock was found to be significantly affected by fish size and feeding regimes. Comparable results were obtained by Akbulut*et al* (2003) who found that, the growth rate and final biomass of rainbow trout were significantly affected by initial stocking size. Also, Duston*et al* (2004) found that, the final biomass of striped bass was affected by the initial stocking size.

Data concerning growth parameters and survival rate in the first experiment are shown in Table (2). The results in (Table 2) indicated that the Nile tilapia broodstock final body weight was increased significantly with decreasing stocking density ($P< 0.05$) especially for male. The highest final body weight was found in the lowest stocking density, 50 fish/ pond, 24 m^2. The same trend has been observed in growth performance parameters, total and daily weight gain and specific growth rate. The same results were obtained by many scientists who confirmed that, growth performance of Nile tilapia broodstock was found to be affected by density of fish, whereas there were a negatively correlation between broodstock density and growth performance of Nile tilapia (El-Sagheer, 2001 and Ahmed *et al.,* 2004).

Table (2). Means of initial and final body weights (g) as well as growth performance parameters of Nile tilapia, *O.niloticus*, broodstock Spawned off-season by controlling environmental conditions and under different management conditions, fish size and density in the presence or absence of feed additive (Nuvisol hatch) during the first experiment.

Treatment	**Body weight**				**Total weight gain (g/fish)**		**ADG (g/fish/day)¹**		**SGR (%/day)²**		**SR (%)³**
	Initial (g/fish)		**Final (g/fish)**								
Feed additives (FA)											
	Male	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**	
Without feed additives	390.41^{a}	239.35^{a}	432.69^{b}	246.63^{b}	42.28^{b}	6.89^{b}	1.48b	0.24^{b}	0.36b	0.11^{b}	100^{a}
With feed additives	390.27^{a}	239.63^{a}	439.19^{a}	249.35a	48.92a	10.17^{a}	1.75a	0.36^{a}	0.42a	0.17^{a}	100^{a}
Different body size (DS)											
	Male	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**	
350 g/fish	435.03^{a}	352.51^{a}	492.29^{a}	360.53^{a}	57.26^{a}	8.01^{b}	2.04^{a}	0.286^{b}	0.443^{a}	0.080^{d}	100^{a}
200 g/fish	393.49^{b}	202.89^{c}	433.32^{b}	212.16^{c}	39.82^{c}	9.28^{a}	1.42^{c}	0.331^{a}	0.344^{d}	0.159^{b}	100^{a}
150 g/fish	345.28^{d}	151.20^{d}	383.15^{c}	160.70^{d}	37.87^{d}	9.50^{a}	1.35^{d}	0.339^{a}	0.371^{c}	0.217^{a}	100^{a}
Mixed size	387.54^{c}	251.24^{b}	434.36^{b}	258.57^{b}	46.81^{b}	7.33^{c}	1.67^{b}	0.262^{c}	0.408^{b}	0.102^{c}	100^{a}
Stocking density (SD)											
	Male	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**	
50 female /pond	426.98^{a}	240.51^{a}	475.23^{a}	248.78^{a}	48.25^{a}	8.94^{a}	1.72^{a}	0.319^{a}	0.405^{a}	0.146^{a}	100^{a}
55 female /pond	386.99^{b}	239.37^{a}	377.55^{b}	247.75^{a}	44.76^{b}	8.38^{ba}	1.59^{b}	0.292^{b}	0.388^{b}	0.137^{b}	100^{a}
60 female /pond	357.04^{c}	238.49^{a}	400.36^{c}	247.44^{a}	43.31^{c}	8.26^{b}	1.54^{c}	0.295^{b}	0.380^{c}	0.135^{b}	100^{a}

The mean in the same column bearing different superscript are significantly different at (P< 0.05).
*1 ADG = Average daily gain (g/fish/day)
*2 SGR= Specific growth rate (%/day)
*3 SR=Survival rate (%).

Effect of Feed additives, body size and stocking densityon Feed and nutrient utilization: Feed additives are important in improving feed efficiency and animal performance. Feed additives augment the nutritional value of feeds or otherwise increase feed efficiency or fish production (Stickney, 2000). The present results (Tables 3) indicated significant differences (P<0.05) in feed and protein intake, feed conversion ratio and protein efficiency ratio for fish received feed additive supplementation (**Nuvisol hatch P®**) as compared with the control diet (without supplementation).

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These parameters were the best for fish fed feed additive diet than the control group (91.37 g/fish, 23.98%, 1.53 and 2.47 vs. 87.49 g/fish, 22.96%, 1.80and 2.11, for feed and protein intake, feed conversion ratio and protein efficiency ratio, respectively). The improvement feed utilization may be due to the acceleration of digestive system maturation and to the increased nutrient digestibility (Tovar-Ramirez *et al.*, 2004) From Table (3) it can be noted that, there were significant ($P<0.05$) differences among different experimental treatments in terms of feed intake, feed conversion ratio (FCR) and protein efficiency ratio (PER) as affected by different broodstock sizes. The results revealed that feed conversion ratio (FCR) and protein efficiency ratio (PER) slightly positively affected bybroodstock size and the statistical analysis supporting this finding. Larger broodstock significantly ($P<0.05$) had a significant higher feed and protein intake values than smaller broodstock sizes. Ahmed *et al*. (2004) found feed conversion ratio was decreased with increasing the initial fish size. The present results are in a parallel line with those reported by Akbulut*et al*. (2003) who found that FCR and daily feeding rate of rainbow trout were significantly ($P<0.05$) influenced by initial stocking size. Duston*et al*. (2004) found that FCR of juvenile striped bass was significantly ($P<0.05$) affected by initial stocking size. These results may be attributed to the fact that the major part of the weight gain is related to the deposition of protein and the protein accretion is a balance between protein anabolism and catabolism (Tahoun, 2007). Data concerning feed utilization of Nile tilapia, *O. niloticus*broodstock, spawned out of season by controlling environmental conditions in the first experimentare shown in Table (3). The results clearly indicated that there were significant differences ($P< 0.05$) in the feed intake, feed conversion ratio, protein intake and protein efficiency ratio due to different stocking density. Feed intake was decreased significantly ($P< 0.05$) with increasing stocking density, where under conditions of low density (50 fish /pond) Nile tilapia broodstock achieved highest feed intake (93.41 g /fish) and the least (86.20g /fish) was in the case of the highest density (60 fish /pond). Siddiqui and Al – Harbi (1999) reported that feed intake was influenced by fish stocking rate. Feed conversion ratio was differing significantly among density treatments (Table 3). Feed conversion ratio was significantly improved at low density by 1.64. The poorest results (1.69) were recorded at fish density 60 fish/pond. This is likely due to low individual fish weight gain at the high density. The protein intake (PI) and protein efficiency ratio (PER) were also significantly affected ($P<0.05$) by the different densities. The best measurements for the above-mentioned parameters were recorded for lower density, while the worst values were in the highest density (Table 2). This is likely due to low individual fish feed intake at high density. Similar trends were observed by Ridha and Cruz (1999) for Nile tilapia broodstock, Hengsawat*et al*. (1997) for African catfish, *Clariasgariepinus*, and Baumgarner*et al*. (2005) for channel catfish, *Ictaluruspunctatus*.

Table (3). Feed and nutrient utilizationof Nile tilapia, *O.niloticus*, broodstockspawned out ofseason by controlling environmental conditions and under different management conditions , fish size and density with and without additive feed (Nuvisol hatch) during the first experiment.

Treatment	Feed intake (g/fish)	FCR[1]	PI[2]	PER[3]
				Feed additives (FA)
Without additives	87.49±2.62^{b}	1.8±0.01^{a}	22.96±0.68^{b}	2.11±0.01^{b}
With additives	91.37±2.44^{a}	1.53± 0.1^{b}	23.98±0.64^{a}	2.47±0.01^{a}
				Different size (DS)
350 g/fish	107.67±0.66^{a}	1.65±0.66^{c}	28.26±0.17^{a}	2.30±0.05^{a}
200 g/fish	81.52±1.50^{c}	1.67±0.04^{ab}	21.39±0.39^{c}	2.28±0.05^{ba}
150 g/fish	78.16±1.73^{d}	1.66±0.04^{bc}	20.51±0.45^{d}	2.30±0.05^{a}
Mix size	90.38±1.39^{b}	1.68±$^{0.04a}$	23.72±0.36^{b}	2.27±0.06^{b}
Stocking density (SD)				
50 fish /m2	93.41±2.62 ^{a}	1.64± 0.029^{b}	24.52±0.69^{a}	2.32±0.041^{a}
55 fish /m	88.68± 3.12^{b}	1.68± 0.038^{a}	23.27±0.81^{b}	2.28±0.051^{b}
60 fish /m2	86.20±3.45^{c}	1.69±0.03^{a}	22.63±0.9^{c}	2.26±0.05^{b}

[*] The mean in the same column bearing different superscript are significantly different at (P< 0.05).
[*1]FCR = Feed Conversion Ratio
[*2] PI= protein intake (g/fish)
[*3]PER= Protein Efficiency Ratio

Effect of Feed additives, body size and stocking densityon seed production: The effects of feed additive (**Nuvisol hatch P®**) on spawning performance of Nile tilapia broodstock were studied during the first experiment, and the results are showed in (Tables 4). The results clearly showed that the diet containing growth promoters and reproductive activity such as **Nuvisol hatch P®** were significantly better in female seed production than the control (454.51 Vs. 421.87 seed /female, respectively), but on the other hand the results clearly showed that the brood fish stocked at low and medium density, 50 and 55 fish/pond, in the case of medium and larger body size and fed on Nuvisol hatch diet were significantly better in average seed production per female than the control and without Nuvisol hatch.

The effects of Nile tilapia broodstock body size on seed production are presented in (Tables 4). It was observed that, the broodstock body size significantly ($P<0.05$) influenced the female fecundity in terms of seed/ female and seed/ female/ day. The medium size female broodstock (200 g) had the highest seed production (464.70 ± 10.06 seed/female) than the largest (350g), smallest(150g) and mixed size female tilapia broodstock (442.22, 421.40 and 424.45 seed/ female, respectively). The results of the present study was confirmed by those of Ridha and Cruz (1989). In contrast, Little and Hulata, (2000) stated that, larger older fish can perform well in intensive hatchery systems, although frequently of spawning and relative clutch size decline with size and age.

Data on the effect of Nile tilapia broodstock stocking density on seed production are presented in (Tables 4). The results of the present work indicated that increasing broodstock density significantly ($P<0.05$) reduced seed production per female. The lower stocking density (50 fish per spawning pond) had the highest seed/ female (466.80± 7.36) and seed/ female/day (19.44± 0.30) followed by medium density, 55 fish (436.± 6.35 seed/ female and 18.20 ± 0.26 seed/female/day) and the highest density (60 fish/pond) recorded the lowest value (410.97± 7.27 seed/ female and17.12 ± 0.30 seed/ female /day). Many researchers studied the effect of different stocking densities on the reproductive performance of Nile tilapia *O. niloticus* and have demonstrated that increasing the level of stocking significantly ($P<0.05$) reduces spawning success and in turn seed production (Bhujel, 2000). The results of the present experiment confirmed that, higher seed production at the lower stocking density compared to other stocking densities indicated more synchronous spawning activity, and increasing the density beyond 3 (2♀:1♂) fish/ m^2 was not effective to improve seed production.

Table (4): Seed productionof Nile tilapia, *O. niloticus*, broodstockspawned out ofseason by controlling environmental conditions and under different management conditions , fish size and density with and without additive feed (Nuvisol hatch) during the first experiment.

Treatment	TS[1]	TSF[2]	SFD[3]
Feed additives (FA)			
Without additives	23112.95±211.56^b	421.87±5.64^b	17.57±0.23^b
With additives	24902.37±325.02^a	454.51±7.36^a	18.93±0.30^a
Different size (DS)			
350 g/fish	24241.60±531.37^b	442.22±10.61^b	18.42±0.44^b
200 g/fish	25470.73±465.45^a	464.70±10.06^a	19.36±0.41^a
150 g/fish	23087.48±288.07^c	421.40±7.95^c	17.55±0.33^c
Mix size	23087.48±81.42^c	424.45±8.48^c	17.68±0.35^c
Stocking density (SD)			
50 fish /m^2	23340.10±368.02^c	466.80±7.36^a	19.44±0.30^a
55 fish /m	24024.37±349.30^b	436.80±6.35^b	18.20±0.26^b
60 fish /m^2	24658.52±436.56^a	410.97±7.27^c	17.12±0.30^c

The mean in the same column bearing different superscript are significantly different at ($P< 0.05$).
TS= Total seed per tank, TSF= Seed / female, SFD= Seed/ female/ day

The Second Experiment

Effect of Feed additives, body size and stocking densityon growth performance and survival rates:
Results in Table (5) proved that the addition of additive feed, **Nuvisol Hatch P®**, has increased the ADG in tilapia broodstock males (1.29 Vs 1.12 g per day in with and without feed additive treatments, respectively), which far outperformed females (0.36 Vs 0.25 g per day). Sharawi (2010) concluded that dietary inclusion of 1 g Nuvisol Hatch P®/Kg diet and 1 g Therigon®/Kg diet before Nile tilapia

mating realized good fish's reproduction and growth performance. Nile tilapia broodstock achieved 100% survival rate in all the treatments of the second experiment (Table 5). These results reflect the extent of suitable environmental and management conditions for fish growth and survival. Similar trends were obtained by Tahuon (2007). Table (5) showed also that there was a positive impact of the size of the broodstock on growth performance parameters, especially in males where the differences were significant ($P < 0.05$), while in the case of females the differences between medium and small sizes only insignificant. Generally, growth rates in males have far outperformed females (Toguyeni*et al.,* 2002). Large male tilapia achieved much higher growth rates than medium, small and mixed sizes, while mixed sizes overtook medium and small sizes in growth performance parameters. In the case of females Nile tilapia, there was a negative correlation between fish body size and growth rate. The highest growth rate achieved in small sizes (0.34 g per day) followed by medium size (0.33 g per day) and then large size (0.27g per day).Mixed fish body size possessed the less rate (0.26 g per day). Comparable results were obtained by Akbulut*et al.,* (2003) who found that, the growth rate and final biomass of rainbow trout were significantly affected by initial stocking size. Also, Duston*et al.,* (2004) found that, the final biomass of striped bass was affected by the initial stocking size.

Average initial and final body weights, individual total weight gain, average daily weight, specific growth rate as well as survival rate of Nile tilapia, *O. niloticus*broodstock, spawned on season under different management conditions especially fish broodstock size and density with and without feed additive (Nuvisol hatch) are shown in Table (5).The results indicated that the males Nile tilapia broodstock final body weight was increased significantly with decreasing stocking density ($P<0.05$), while in the case of females the differences were insignificant due to stocking density. The highest final body weight was found in low stocking density, 50 fish/pond, 24 m^2 (457.75 and 248.78 g, for male and female, respectively).The same trend has been observed in growth performance parameters, total and daily weight gain and specific growth rate. Similar results were obtained by many scientists who confirmed that, growth performance of Nile tilapia broodstock was affected by the density of fish, whereas there were a negatively correlation between broodstock density and growth performance (El-Sagheer, 2001 and Ahmed *et al.,* 2004).

Table (5): Means of initial and final body weights(g) as well as growth performance parameters of Nile tilapia, *O.niloticus*, broodstock spawned on season, the summer of 2011, under different management conditions, fish size and density in the presence or absence of feed additive (Nuvisol hatch) during the second experiment.

Treatment	Body weight Initial (g/fish)		Body weight Final (g/fish)		Total weight gain (g/fish)		ADG (g/fish/day)3		SGR (%/day)4		SR
Feed additives (FA)											
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	
Without additives	381.42a	239.46a	412.79b	246.35b	31.36b	6.89b	1.12b	0.246b	0.280b	0.112b	100 a
With additives	381.07b	239.46a	417.46a	249.63a	36.38a	10.17a	1.29a	0.363a	0.323a	0.167a	100 a
Different size (DS)											
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	
350 g/fish	431.66a	352.51a	477.42a	360.52a	45.75a	8.01b	1.63a	0.286b	0.360a	0.080d	100 a
200 g/fish	376.94c	202.88c	404.99c	212.16c	28.05c	9.28a	1.01c	0.331a	0.257d	0.159b	100 a
150 g/fish	331.28d	151.21d	357.85d	160.71d	26.57d	9.50a	0.94d	0.339a	0.276c	0.217a	100 a
Mix size	385.10b	251.24b	420.22b	258.57b	35.12b	7.33c	1.25b	0.262c	0.312b	0.102c	100 a
Stocking density (SD)											
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	
50 female/pond	422.75a	238.49a	457.75a	248.78a	35.0a	8.94a	1.251a	0.319a	0.281b	0.146a	100 a
55 female/pond	377.55b	239.37a	412.58b	247.76a	35.02a	8.38ba	1.25a	0.299ba	0.312a	0.137b	100 a
60 female/pond	343.44c	240.52a	375.04c	247.44a	31.60b	8.26b1.128		0.295b	0.312a	0.135b	100 a

* The mean in the same column bearing different superscript are significantly different at (P< 0.05).
*1 ADG = Average daily gain (g/fish/day)
*2 SGR= Specific growth rate (%/day)
*3 SR=Survival rate (%)

Effect of Feed additives, body size and stocking densityon feed and nutrient utilization: Effect of feed additive on feed utilization parameters of Nile tilapia, *O. niloticus*, during the second experiment are presented in Table (6). The results showed that broodstock Nile tilapia (Group II) fed on Nuvisol hatch diet had the best feed conversion ratio and also protein efficiency ratio by 1.53 and 2.39 respectively, compared with the first group fed on diet without Nuvisol hatch, 1.53 feed units as a While the first group have achieved only 1.84 and 1.99 for FCR and PER, respectively (Table 6).The importance of feed additives and quality has been reported by many workers for enhancing fish growth, feed utilization and reproductive performance parameters (El-Ezabi*et al*., 2011 as well as Essa*et al*., 2011).

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Average feed intake, feed conversion ratio, protein intake and protein efficiency ratio of Nile tilapia, *O.niloticus*broodstock, spawned on the natural spawning season under different management conditions especially fish broodstock size and density with and without feed additive (Nuvisol hatch) are shown in Table (6). From the results of second experiment it can be noted that, there were significant (P<0.05) differences among different experimental treatments in terms of feed intake, feed conversion ratio (FCR) and protein efficiency ratio (PER) as affected by different broodstock sizes .The results revealed also that, large broodstock Nile Tilapia achieved the highest rate of feed intake (89.26 g / fish), followed by the treatment with mixed sizes (71.65 g / fish). Also treatment with large sizes achieved better feed conversion ratio (1.66) while no significant differences amang the treatments with mixed sizes, small and medium were found in feed conversion ratio, where it ranged between 1.69 and 1.70. The larger broodstock significantly (P<0.05) had higher protein intake and PER values (24.30 g per fish and 2.21, respectively) than small, medium and mixed broodstock sizes, where were no significant differences among them (PER in these treatments ranged between 2.17 and 2.19). These results may be attributed to the fact that the major part of the weight gain is related to the deposition of protein and the protein accretion is a balance between protein anabolism and catabolism.Ahmed *et al*. (2004) found significant (P<0.05) effects of dietary protein levels and initial stocking sizes on feed conversion ratio, where FCR was decreasing the initial fish size.

The average values of feed intake (g/fish), feed conversion ratio (FCR), protein intake (PI) and protein efficiency ratio (PER) of Nile tilapia, *O. niloticus*broodstock, spawned on natural spawning season under different management conditions especially fish broodstock size and density with and without feed additive (Nuvisol hatch),are shown in Table (6). The results clearly indicated that there were significant differences (P<0.05) in the feed intake, feed conversion ratio, protein intake and protein efficiency ratio due to different stocking density. Feed intake was decreased significantly (P<0.05) with increasing stocking density, where under conditions of low density (50 fish /pond) Nile tilapia broodstock achieved highest feed intake (73.92 g /fish) and the least (66.33 g /fish) in the case of highest density (60 fish /pond). Siddiqui and Al – Harbi (1999) reported that feed intake was influenced by fish stocking rate.

Feed conversion ratio was significantly differed among density treatments (Table 6). Feed conversion ratio was significantly improved at medium and high density by 1.68. The poorest results (1.70) were recorded at fish lowest density, 50 fish/ pond. This is likely due to high individual fish feed intake at lowest density. The protein intake (PI) and protein efficiency ratio (PER) were also significantly affected (P<0.05) by the different densities. Although under the conditions of high density (60 fish /m^2), the value of protein intake was the least (18.06), this treatment has realized the best utilization use of the protein, PER (2.20) was higher than its corresponding values in the small and medium densities by 0.46 and 1.38 respectively (Table 6).This is likely due to low individual fish protein intake and good weight gain at high density during the present experiment. Similar trends were observed by Essa (2000) for hybrid tilapia, *Oreochromisniloticus*& *O. aureus*, reared in cages.

Table (6): Feed and nutrient utilization of Nile tilapia, *O.niloticus*, broodstock spawned on season, the summer of 2011, under different management conditions , fish size and density with and without feed additive (Nuvisol hatch) during the second experiment.

Treatment	Feed intake (g/fish)	FCR[1]	PI[2]	PER[3]
Feed additives (FA)				
Without additives	70.43±2.99[b]	1.84±0.00[a]	19.17±0.81[b]	1.99±0.00[b]
With additives	71.51±2.25[a]	1.53±0.00[b]	19.47±0.61[a]	2.39±0.00[a]
Different size (DS)				
350 g/fish	89.26±2.68[a]	1.66±0.04[b]	24.30±0.73[a]	2.21±0.05[a]
200 g/fish	62.44±1.24[c]	1.69±0.04[ba]	17.00±0.33[c]	2.18±0.05[b]
150 g/fish	60.51±0.92[d]	1.69±0.04[a]	16.48±0.25[d]	2.19± 0.06[b]
Mix size	71.65±1.48[b]	1.70±0.05[a]	19.51±0.40[b]	2.17±0.06[b]
Stocking density (SD)				
50 fish /m^2	73.92±2.96 [a]	1.70±0.03[a]	20.12±0.80[a]	2.17±0.04[b]
55 fish /m	72.66± 4.01[b]	1.68±0.03[a]	19.78±1.09[b]	2.19± 0.05[ba]
60 fish /m^2	66.33±2.31[c]	1.68±0.04[a]	18.06±0.63[c]	2.20±0.05 [a]

The mean in the same column bearing different superscript are significantly different at ($P< 0.05$).
[*1]FCR = Feed Conversion Ratio
[*2] PI= protein intake (g/fish)
[*3]PER= Protein Efficiency Ratio

Effect of Feed additives, body size and stocking densityon seed production: During the second experiment, the effects of feed additive, **Nuvisol Hatch P®**, on spawning performance of Nile tilapia broodstock were studied and the results are showed in Table (7).The results clearly showed that the diet containing Nuvisol Hatch were significantly improve female seed production than the control (472.66 Vs 431.96 seed /female, respectively). The effects of Nile tilapia broodstock body size on seed production are presented in Table (7). It was observed that, the broodstock body size significantly ($P<0.05$) influenced the female fecundity in terms of seed/ female and seed/female/ day. The medium size female broodstock (200g) had a highest seed production (474.48 ± 9.47 seed/female) than largest (350 g), smallest (150g) and mixed size female tilapia broodstock (457.36 ± 11.22, 426.03 ± 10.52 and 451.63 ± 8.12 seed/female, respectively).The results of the present study was confirmed by those obtained by Ridha and Cruz (1989). Data on the effect of Nile tilapia broodstock stocking density on Nile tilapia seed production are presented in Table (7). The results of the present work indicated that increasing broodstock density significantly ($P<0.05$) reduced seed production per female despite of the increase in seed production per each spawning concrete pond due to the increase the intensity of broodstock. The lower stocking density (50 fish per spawning pond) had the highest seed/ female (478.90 ± 7.65) and seed/ female/day (17.1 0± 0.27) followed by medium density, 55 fish (454.07 ± 7.59 seed/ female and 16.21 ± 0.27seed/ female/ day) and in the latest highest density, 60 fish (423.96 ± 7.68 seed/ female and 15.14 ± 0.27 seed/ female /day). Many researchers studied the effect of different stocking densities on the reproductive performance of Nile tilapia *O. niloticus* and have demonstrated that increasing the level of stocking significantly ($P<0.05$) reduces spawning success and in turn seed production (Bhujel, 2000). From previous results, in order to obtain high quantity and quality of Nile tilapia seeds of Nile tilapia spawning season, it is recommended to use medium and large broodstock (1-2 years old) at a stocking density 3 (2♀:1♂) fish/ m2, about 50 or 55 per concrete spawning pond, 24 m^2 with feed additive, **Nuvisol Hatch P®**.

Table (7): Means of seed production in terms of total seed (TS), total seed per female (TSF) and seed production per female per day (SFD) of Nile tilapia, O.niloticus, broodstock spawned on season, during the second experiment.

Treatment	TS	TSF	SFD
Feed additives (FA)			
Without additives	23674.49±288.00[b]	431.96±6.22[b]	15.42±0.22[b]
With additives	25896.87±274.60[a]	472.66±6.73[a]	16.88±0.24[a]
Different size (DS)			
350 g/fish	25078.95±593.96[b]	457.36±11.22[b]	16.33±0.40[b]
200 g/fish	26016.98±473.33[a]	474.48±9.47[a]	16.94±0.33[a]
150 g/fish	23325.56±395.23[d]	426.03±10.52[d]	15.21±0.37[d]
Mix size	24721.21±195.74[c]	451.36±8.12[c]	16.12±0.28[c]
Stocking density (SD)			
50 fish /m^2	23945.20±382.96[c]	478.90±7.65[a]	17.10±0.27[a]
55 fish /m	24973.90±417.45[b]	454.07±7.59[b]	16.21±0.27[b]
60 fish /m^2	25437.93±460.89[a]	423.96±7.68[c]	15.14±0.27[c]

[*] The mean in the same column bearing different superscript are significantly different at ($P< 0.05$).
TS= Total seed per tank, TSF= Seed / female, SFD= Seed/ female/ day.

Comparing the results of the economic analysis (Tables 8, 9, 10, 11, 12, and 13) of the two experiments showed that the total production of Nile tilapia fry per each spawning pond, 24 m^2, is 28,090 within the natural spawning season, an increase of 2.23% from that was spawning outside the normal spawning season (27478 fry). Though total revenue and net income under hatchery conditions in the out off-season (February 2010) much higher than that in natural spawning season (April 2011) by 22.01%**.** This is of course due to the price of tilapia fry in the winter months is higher than the summer to supply shortages in winter and increased demand at the same time. This is due to the farmers need to start the growing season early, March/April, in order to harvest their fish before temperatures drop in the next winter, which adversely affect the life of the fish.

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Table (8). Average operational costs per cycle (28 days) of Nile tilapia, *O.niloticus*, broodstock spawned out of season by controlling environmental conditions and under different management conditions, fish broodstock size and density in the presence or absence of feed additive (Nuvisol hatch).

Treatment	Feed costs (3.1 LE/kg), 26% protein	brood stock cost (0.5 LE/fish)	Labor cost (750 LE/month), 3 labors for 40 ponds/28 days	Rent pond,	Depreciation gasoline, heater …..etc	Total operational costs
1-SD50*DS350*FAa	25.25	35.00	60.00	160	335.00	616.25
2-SD50*DS350*FAc	24.50	35.00	60.00	160	335.00	616.50
3-SD50*DS200*FAa	18.66	35.00	60.00	160	335.00	611.66
4-SD50*DS200*FAc	19.11	35.00	60.00	160	335.00	613.11
5-SD50*DS150*FAa	20.62	35.00	60.00	160	335.00	615.62
6-SD50*DS150*FAc	17.81	35.00	60.00	160	335.00	613.81
7-SD50*DSMIX*FAa	25.45	35.00	60.00	160	335.00	622.45
8-SD50*DSMIX*FAc	26.02	35.00	60.00	160	335.00	624.02
9-SD55*DS350*FAa	20.90	38.50	60.00	160	335.00	623.40
10-SD55*DS350*FAc	19.94	38.50	60.00	160	335.00	623.44
11-SD55*DS200*FAa	18.18	38.50	60.00	160	335.00	622.68
12-SD55*DS200*FAc	18.37	38.50	60.00	160	335.00	623.87
13-SD55*DS150*FAa	29.70	38.50	60.00	160	335.00	636.20
14-SD55*DS150*FAc	28.65	38.50	60.00	160	335.00	636.15
15-SD55*DSMIX*FAa	20.70	38.50	60.00	160	335.00	629.20
16-SD55*DSMIX*FAc	19.06	38.50	60.00	160	335.00	628.56
17-SD60*DS350*FAa	20.61	42.00	60.00	160	335.00	634.61
18-SD60*DS350*FAc	18.90	42.00	60.00	160	335.00	633.90
19-SD60*DS200*FAa	20.58	42.00	60.00	160	335.00	636.58
20-SD60*DS200*FAc	20.10	42.00	60.00	160	335.00	637.10
21-SD60*DS150*FAa	23.05	42.00	60.00	160	335.00	641.05
22-SD60*DS150*FAc	21.79	42.00	60.00	160	335.00	640.79
23-SD60*DSMIX*FAa	24.61	42.00	60.00	160	335.00	644.61
24-SD60*DSMIX*FAc	21.36	42.00	60.00	160	335.00	642.36

SD: Stocking density; DS: Body size; FA: Feed additive; a: with; c: control

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Table (9): The most important features of the economic analysis of income and costs for Nile tilapia, *O.niloticus*, broodstock spawned out of season by controlling environmental conditions and under different management conditions, fish broodstock size and density in the presence or absence of feed additive (Nuvisol hatch).

Treatment	Total seeds/pond	Total operational costs (LE/pond)	Average revenue (LE/pond)	Average net income (LE/pond)
1-SD50*DS350*FAa	24844	616.25	993.78	377.53
2-SD50*DS350*FAc	21600	616.50	864.04	247.54
3-SD50*DS200*FAa	26123	611.66	1044.93	433.27
4-SD50*DS200*FAc	23487	613.11	939.50	326.40
5-SD50*DS150*FAa	23015	615.62	920.62	305.00
6-SD50*DS150*FAc	21728	613.81	869.12	255.31
7-SD50*DSMIX*FAa	22791	622.45	911.67	289.22
8-SD50*DSMIX*FAc	23129	624.02	925.16	301.15
9-SD55*DS350*FAa	25720	623.40	1028.80	405.40
10-SD55*DS350*FAc	23342	623.44	933.71	310.27
11-SD55*DS200*FAa	26613	622.68	1064.54	441.86
12-SD55*DS200*FAc	23386	623.87	935.47	311.61
13-SD55*DS150*FAa	24232	636.20	969.28	333.08
14-SD55*DS150*FAc	22324	636.15	892.97	256.83
15-SD55*DSMIX*FAa	23196	629.20	927.85	298.66
16-SD55*DSMIX*FAc	23378	628.56	935.16	306.60
17-SD60*DS350*FAa	26861	634.61	1074.45	439.84
18-SD60*DS350*FAc	23079	633.90	923.20	289.29
19-SD60*DS200*FAa	27477	636.58	1099.12	462.54
20-SD60*DS200*FAc	25735	637.10	1029.41	392.31
21-SD60*DS150*FAa	24332	641.05	973.31	332.26
22-SD60*DS150*FAc	22892	640.79	915.68	274.90
23-SD60*DSMIX*FAa	23619	644.61	944.77	300.17
24-SD60*DSMIX*FAc	23269	642.36	930.78	288.43

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Table (10): Economic evaluation parameters of Nile tilapia, *O.niloticus*, broodstock spawned out of season by controlling environmental conditions and under different management conditions, fish broodstock size and density in the presence or absence of feed additive (Nuvisol hatch).

Treatment	1) Percentage of operating (%)	2) Return on sales (%)	3) Return on costs (%)	6) Rate of return as a % of total inputs
1-SD50*DS350*FAa	49.61	51.30	201.58	103.41
2-SD50*DS350*FAc	57.08	43.96	175.19	77.01
3-SD50*DS200*FAa	46.83	53.94	213.54	115.18
4-SD50*DS200*FAc	52.21	48.64	191.55	93.18
5-SD50*DS150*FAa	53.50	47.46	186.93	88.72
6-SD50*DS150*FAc	56.50	44.50	176.99	78.77
7-SD50*DSMIX*FAa	54.62	46.26	183.08	84.69
8-SD50*DSMIX*FAc	53.96	46.91	185.32	86.93
9-SD55*DS350*FAa	48.48	52.46	206.29	108.22
10-SD55*DS350*FAc	53.42	47.61	187.21	89.14
11-SD55*DS200*FAa	46.79	54.03	213.70	115.47
12-SD55*DS200*FAc	53.35	47.59	187.43	89.20
13-SD55*DS150*FAa	52.51	48.52	190.44	92.41
14-SD55*DS150*FAc	56.99	44.12	175.47	77.42
15-SD55*DSMIX*FAa	54.25	46.70	184.33	86.08
16-SD55*DSMIX*FAc	53.77	47.17	185.97	87.72
17-SD60*DS350*FAa	47.25	53.72	211.64	113.69
18-SD60*DS350*FAc	54.93	46.11	182.05	83.94
19-SD60*DS200*FAa	46.33	54.54	215.83	117.71
20-SD60*DS200*FAc	49.51	51.42	201.97	103.85
21-SD60*DS150*FAa	52.69	48.39	189.79	91.84
22-SD60*DS150*FAc	55.98	45.16	178.62	80.67
23-SD60*DSMIX*FAa	54.58	46.43	183.21	85.07
24-SD60*DSMIX*FAc	55.21	45.82	181.13	82.99

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Table (11): Average operational costs per cycle (24 days) of Nile tilapia, *O.niloticus*, broodstock spawned on season, the summer of 2011, under different management conditions, fish size and density in the presence or absence of feed additive (Nuvisol hatch) during the second experiment.

Treatment	Feed costs (3.1 LE/kg), 26% protein	brood stock cost (0.5 LE/fish)	Labor cost (…750 LE/month), 3 labors for 40 ponds/24days	rent pond	Depreciation, gasoline, …..etc	Total operational costs
1-SD50*DS350*FAa	21.24	35.00	60.00	160	165	442.24
2-SD50*DS350*FAc	20.19	35.00	60.00	160	165	442.19
3-SD50*DS200*FAa	14.49	35.00	60.00	160	165	437.49
4-SD50*DS200*FAc	12.83	35.00	60.00	160	165	436.83
5-SD50*DS150*FAa	14.82	35.00	60.00	160	165	439.82
6-SD50*DS150*FAc	14.65	35.00	60.00	160	165	440.65
7-SD50*DSMIX*FAa	20.88	35.00	60.00	160	165	447.88
8-SD50*DSMIX*FAc	25.39	35.00	60.00	160	165	453.39
9-SD55*DS350*FAa	16.84	38.50	60.00	160	165	449.34
10-SD55*DS350*FAc	15.93	38.50	60.00	160	165	449.43
11-SD55*DS200*FAa	13.81	38.50	60.00	160	165	448.31
12-SD55*DS200*FAc	13.83	38.50	60.00	160	165	449.33
13-SD55*DS150*FAa	22.20	38.50	60.00	160	165	458.70
14-SD55*DS150*FAc	21.81	38.50	60.00	160	165	459.31
15-SD55*DSMIX*FAa	16.36	38.50	60.00	160	165	454.86
16-SD55*DSMIX*FAc	14.49	38.50	60.00	160	165	453.99
17-SD60*DS350*FAa	15.89	42.00	60.00	160	165	459.89
18-SD60*DS350*FAc	16.58	42.00	60.00	160	165	461.58
19-SD60*DS200*FAa	17.11	42.00	60.00	160	165	463.11
20-SD60*DS200*FAc	16.58	42.00	60.00	160	165	463.58
21-SD60*DS150*FAa	17.91	42.00	60.00	160	165	465.91
22-SD60*DS150*FAc	17.64	42.00	60.00	160	165	466.64
23-SD60*DSMIX*FAa	18.11	42.00	60.00	160	165	468.11
24-SD60*DSMIX*FAc	16.61	42.00	60.00	160	165	467.61

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Table (12): The most important features of the economic analysis of Nile tilapia, O.niloticus, broodstock spawned on season, the summer of 2011, under different management conditions, fish size and density in the presence or absence of feed additive (Nuvisol hatch) during the second experiment.

Treatment	Total seeds/pond	Total operational costs (LE/pond)	Average revenue (LE/pond)	Average net income (LE/pond)
1-SD50*DS350*FAa	25530.05	442.24	765.90	323.66
2-SD50*DS350*FAc	21899.76	442.19	656.99	214.80
3-SD50*DS200*FAa	26589.95	437.49	797.70	360.21
4-SD50*DS200*FAc	23432.65	436.83	702.98	266.15
5-SD50*DS150*FAa	23720.64	439.82	711.62	271.80
6-SD50*DS150*FAc	22292.50	440.65	668.78	228.13
7-SD50*DSMIX*FAa	24654.51	447.88	739.64	291.76
8-SD50*DSMIX*FAc	23441.52	453.39	703.25	249.86
9-SD55*DS350*FAa	26695.30	449.34	800.86	351.52
10-SD55*DS350*FAc	24913.63	449.43	747.41	297.98
11-SD55*DS200*FAa	27153.63	448.31	814.61	366.30
12-SD55*DS200*FAc	24621.23	449.33	738.64	289.31
13-SD55*DS150*FAa	25006.62	458.70	750.20	291.50
14-SD55*DS150*FAc	21390.98	459.31	641.73	182.42
15-SD55*DSMIX*FAa	25172.50	454.86	755.18	300.32
16-SD55*DSMIX*FAc	24837.31	453.99	745.12	291.13
17-SD60*DS350*FAa	27896.77	459.89	836.90	377.01
18-SD60*DS350*FAc	23538.24	461.58	706.15	244.57
19-SD60*DS200*FAa	28089.95	463.11	842.70	379.59
20-SD60*DS200*FAc	26214.46	463.58	786.43	322.86
21-SD60*DS150*FAa	24756.62	465.91	742.70	276.79
22-SD60*DS150*FAc	22786.03	466.64	683.58	216.94
23-SD60*DSMIX*FAa	25495.88	468.11	764.88	296.77
24-SD60*DSMIX*FAc	24725.54	467.61	741.77	274.16

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Table (13): Economic evaluation parameters of Nile tilapia, O.niloticus, broodstock spawned on season, the summer of 2011, under different management conditions , fish size and density in the presence or absence of feed additive (Nuvisol hatch) during the second experiment.

Parameters	1) Percentage of operating (%)	2) Return on sales (%)	3) Return on costs (%)	6) Rate of return as a % of total inputs
Treatments				
1-SD50*DS350*FAa	49.49	51.75	202.05	104.55
2-SD50*DS350*FAc	57.69	43.75	173.34	75.83
3-SD50*DS200*FAa	47.01	54.07	212.72	115.01
4-SD50*DS200*FAc	53.26	47.96	187.75	90.04
5-SD50*DS150*FAa	52.98	48.32	188.76	91.21
6-SD50*DS150*FAc	56.48	44.90	177.07	79.50
7-SD50*DSMIX*FAa	51.90	49.26	192.67	94.90
8-SD50*DSMIX*FAc	55.26	45.96	180.96	83.17
9-SD55*DS350*FAa	48.09	53.18	207.94	110.57
10-SD55*DS350*FAc	51.54	49.81	194.02	96.65
11-SD55*DS200*FAa	47.17	53.99	211.99	114.44
12-SD55*DS200*FAc	52.14	49.13	191.79	94.23
13-SD55*DS150*FAa	52.41	48.98	190.81	93.45
14-SD55*DS150*FAc	61.35	40.27	163.00	65.64
15-SD55*DSMIX*FAa	51.63	49.62	193.69	96.11
16-SD55*DSMIX*FAc	52.22	49.04	191.48	93.90
17-SD60*DS350*FAa	47.10	54.21	212.31	115.09
18-SD60*DS350*FAc	56.03	45.53	178.48	81.26
19-SD60*DS200*FAa	47.10	54.12	212.29	114.89
20-SD60*DS200*FAc	50.53	50.78	197.92	100.51
21-SD60*DS150*FAa	53.77	47.72	185.98	88.75
22-SD60*DS150*FAc	58.51	43.10	170.90	73.67
23-SD60*DSMIX*FAa	52.46	48.89	190.63	93.19
24-SD60*DSMIX*FAc	54.03	47.35	185.07	87.64

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