PERFORMANCE OF NILE TILAPIA (*OREOCHROMIS NILOTICUS*) RAISED IN CAGES AS AFFECTED WITH STOCKING DENSITY AND DIETARY PROTEIN LEVEL

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ABSTRACT

An experiment was conducted on 16 floating cages, each of a total water volume of $1m^3$ stocked with Nile tilapia fingerlings weighing 30.07 to 30.22 g at the experimental start. The 16 cages represented four stocking densities (80 D1; 100 D2; 120 D3 and 140 D4 fish/m^3) and four protein levels within each density tested (P1 20 ; P2 24 ; P3 28 and P4 32%). The experiment lasted 6 months after start. Results obtained are summarized in the following:

(1) Increasing the protein level within each stocking density increased significantly (P<0.05) both body weights and length of fish.

(2) Within each protein level tested, increasing the stocking density resulted in significant decreases in body weight and length of Nile tilapia

(3) Both protein levels and stocking densities released significant effects on gains in live weights, specific growth rate, feed conversion ratio and protein efficiency ratio. The total cage yield differed among the

where fish at a density of 120 fish/m^3 fed on the diet with 32% protein gave the highest yield of marketable size fish.

INTRODUCTION

Fish cage culture has been defined as the rearing of fish stocks, generally from juvenile to market size, in a totally connected water volume through which a free water circulation is maintained. Tilapia cage culture has a relatively short history. The first scientific experimentation started around 1970 with the rearing of *T. aurea* in cages placed in fish ponds in Alabama U.S.A. (Suwanasart, 1971 and Armbrester, 1971) Because of some Tilapia inherent advantages such as possibility of using existing tropical and subtropical water bodies to produce a fast growing and well appreciated fish; tilapia cage culture is giving more and more interest throughout developing tropical regions in particular.

The aim of the present work was to study the growth response of Nile Tilapia (*Oreochromis niloticus*) raised in cages under different stocking densities and dietary protein levels.

MATERIAL AND METHODS

This study was carried out at Abbassa Fish Hatchery belonging to the General Authority for Fish Resources Development-Ministry of Agriculture, ARE. The hatchery is located in Sharkiya Governorate. For the Purpose of the study four units of surface floating cages with four cages each were constructed and made of an external and internal iron frames with quadratic shape. The external shape was constructed to have diameters of 4x4 m, and the internal one had the diameters 3.5 x 3.5 m. The space between the internal and external frames of each cage unit was covered with wood plates used as a gate for the daily work. In order to insure the floating of the cage unit, three styrofoam blocks were closely connected to each side of the external frame of each unit. Cages were formed inside each cage unit, using polyethylene net (100 x 100 X 150 cm.) with a mesh size of 15 mm, to give a net water volume of each cage of one cubic meter. After the complete construction of the four cage units, they were fixed in an earthen pond with a total area of one feddan (4200 m^2) with a water depth of 1.8 m at its deepest point. The four cage units represented four stacking densities of Nile Tilapia, which were 80(D1), 100(D2), 120 (D3) and 140 (D4) fish/m^3 of the cage respectively. Within each stocking density tested, four dietary protein levels were applied i.e. 20%(P1), 24%(P2), 28% (P3) and 32% (P4) percent, respectively. The Total number of the experimental cages was16 cages representing the four stocking densities, within each four protein levels were tested on Nile Tilapia during an experimental period of 6 months. The experimental design is illustrated in the following:

Cage unit (1)- stocking Density D1 80 fish / M^3	20% protein p1 (D1 P1)
	24% protein P2 (D1 P2)
	28% protein P3 (D1 P3)
	32% protein P4 (D1 P 4)
Cage unit (2)- stocking Density D2 100 fish/m^3	20% protein p1 (D2 P1)
	24% protein P2 (D2 P2)
	28% protein P3 (D2 P3)
	32% protein P4 (D2 P 4)
Cage unit (3)- stocking Density D3 120 fish/m^3	20% protein p1 (D3 P1)
	24% protein P2 (D3 P2)
	28% protein P3 (D3 P3)
	32% protein P4 (D3 P 4)
Cage unit (4)- stocking Density D4 140 fish/m^3	20% protein p1 (D4 P1)
	24% protein P2 (D4 P2)
	28% protein P3 (D4 P3)
	32% protein P4 (D4 P 4)

At the start of the experiment, Nile Tilapia fingerlings averaging in weight from 29.6± 0.68 to 30.3 ± 0.08 g were randomly allocated into the sixteen treatments as cited before, representing 4 stocking densities, within each four protein levels. The composition of the experimental diets is given in (Table 1). The diets were formulated to contain similar gross energy ranging between 3198 to 3303 Kcal/Kg of diet and made from available local feed ingredients. The ingredients of each diet were grinded using a feed grinder then sieved to a particle size of less than 0.5 mm. The grinded ingredients of each experimental diet were weighed and mixed together by a horizontal mixer to assure complete homogeneity of the complete ration. The homogenous diet mixtures were processed to pellets of 3 and 4 mm diameter using a pelleting machine. The experimented diets were fed at a rate of 3% of the total biomes as of each cage twice daily at 9 a.m. and 3 p.m. in equal portions at water temperature lower than 16 °C and at water temperatures above 16 °C to 21 °C the feeding rate was reduced to 2 % of the cage biomass according to Bardach *et al.* (1972).

The experimental diets were fed 6 days a week. The pellet size was 3 mm for the fish weighing 20 to100 g and 4 mm for that weighing 100 to 250 g respectively. The quantity of diets was estimated according to the average fish weight after the monthly sampling for the following period till the next sampling as described by Elliott (1975).

Monthly samples each of 40 individuals were caught from each experimental cage and individual body weights to the nearest gram and body length to the nearest 0.1 mm were recorded. Other parameters as absolute growth rate (AGR), percentage weight gain (PWG), specific growth rate (SGR), feed conversion ratio (FCR), protein efficiency ratio (PER) were calculated. At the start of the experiment, ten fish were taken randomly and at the end of the experimental period ten fish were taken randomly from each cage treatment and exposed individually to the whole body analysis. Analysis of diets and feed ingredients for the proximate analysis were carried out according to the methods described by A.O.A.C (1980). Gross energy contents in the diets were calculated using the values of 5.5; 9.1 and 4.1 kcal/g for protein, fat and carbohydrates respectively according to Juancy and Ross (1982). Dissolved oxygen contents in cage water were determined daily during the whole experimental period at 6 a.m. and water temperature was recorded two times (8 a.m. and 3 p.m.) daily using a thermometer at a depth of 25 cm. Water pH measurements were performed one time weekly, using pH. Meter model consort. Water conductivity and total alkalinity were determined biweekly throughout the experimental period as described by Boyed (1979). All water quality parameters tested throughout the experimental period revealed that all parameters were within the permissible levels for optimum fish growth .The statistical evaluation of results was carried out according to the methods described by Sndecor and Cochron (1976), and Duncan (1955) multiple range test was performed to detect the significant differences among the means.

RESULTS AND DISCUSSION

Body Weight (Bw) and Body length (Bl)

Results presented in Table (2) show the effect of protein level within each stocking density tested, regardless of stocking density and the grand means of stocking density regardless of protein level on final weights of Nile Tilapia reared in cages. These results indicate that averages of initial weights in all experimental groups had ranged between 29.6 and 30.3 g and differences in initial weights among the experimental groups were insignificant, indicating the complete randomization of dividing the individuals in experimental groups at the start. As presented in the same table, averages of final weights within each density tested increased significantly ($P<0.05$) with each increase in the dietary protein level and the highest weights were obtained with the 32 % protein level followed in a descending order by the 28; 24 and 20% protein levels respectively. Results of (Table 2) show also that groups reared under lower stocking densities had higher final weight compared with their corresponding groups fed on the same protein level but stocked at higher densities.

Regardless of stocking density averages of final weights as affected with protein level fed for protein levels p1, p2, p3 and p4 were 132.5; 170.6; 193.2 and 270.6 g. respectively (Table 2). The analysis of variance of results showed that final weights of Nile Tilapia increased significantly ($p<0.05$) almost in a significant ($p<0.05$) linear manner with each increase in the level of dietary protein, regardless of stocking density.

Average percentage of increase in final body weights due to protein level fed relative to those of the lowest protein level (P1), regardless of stocking density were 100; 128.7; 145.8 and 158.9% for P1, P2, P3 and P4 respectively. There results may lead to believe that the dietary protein requirements of Tilapia reared in cages and depending only on artificial feeds lie between 28 to 32%. These results are in complete agreement with that of Cruz Laudenica (1976) and Hughes (1977), who reported that Tilapia at a size of 10-30g requires a dietary protein level of 25 to 30%. Results of Viola and Zohar (1984) showed also that increasing the protein level in diets of Tilapia hybrid (*O. niloticus* x *O. aureus*) from 25% to 30 0r 35% increased significantly growth rate. Also Wang *et al.* (1985a) reported that increasing the protein level from 13 to 40% in Tilapia diets increased fish growth performance and the best performance was obtained by group fed on the 30% protein diet.

Data of Table 2 show that averages of final weights as affected with stocking density regardless of protein level fed decreased in a significant ($P<0.05$) linear manner with each increase in the stocking density. Percentage of changes in the final weights due to the effect of density relative to the lowest weights of D4 were 124.3; 122.1 and 113.1% for D1; D2 and D3 respectively. Based on the results presented in Table (2) it could be concluded that Tilapia reared in cages produced the heaviest weights at harvesting (6 month fattening period) when stocked at a rate of 80 fish/m^3. These results are in agreement with Coach (1976), who reported that growth rate of caged fish decreased with proincreasing stock but the total production increased up to 36 to 50 Kg/m^3. Similarly, Moav *et al.* (1977); Barlin (1979), who showed that growth depression of fish stocked at higher rates may atribute to crowding: Social interactions and aggression.

Moreover, differences in initial body length did not differ significantly among the treatment groups (Table 3). At the end of the experimental period, final length within each stocking density tested increased with each increase in dietary protein level fed and the increases in body length were more pronounced ($p < 0.05$) at the two higher densities tested. Regardless of stocking density, averages of final body length was affected with protein levels for p1, p2, p3 and p4 were 19.3, 20.4, 20.8 and 21.3 cm, respectively. The statistical evaluation of results show that fish fed on the 32 % protein diet (p4) had significantly ($p < 0.05$) longer bodies followed in a significant decreasing order by both p3 and p2 then p1 respectively. These results support those of Lovell *et al.* (1974), who stated that, the optimal protein level in practical diets of warm water fish was about 30 to 36 % and higher protein levels were required for maximum growth rate in all- plant protein diets than in diets containing some fish meal.

In this regards, Osman (1988) showed that the highest body length records were obtained in Nile Tilapia using a diet containing 30.14% crude protein and 3902/Kcal/ME /Kg of the diet. He added that final body length of Tilapia increased with each increase in protein level fed up to 30.14% and each increase in the dietary protein level above this level did not influence the final body length.

Regarding the effect of stocking density on body length, results of (Table 3) Show that there were slight insignificant decreases in body length with increasing stocking density from 80 to 100 or 120 fish/m^3 and there were significant ($p<0.05$) decrease in length of fish stocking at 140 fish/m^3. These results are in accordance with those of Hafez (1991), who showed that body lenngth of fish decreases with increasing stocking density . Also Abdel.Hakim *et al.* (1995) showed that body length of Nile Tilapia stocked at rates of 3000;4500 and 600 Fish/Feddan after 16 weeks of treatments were 6.49; 6.29 and 5.71 cm for males while for females body length records were 5.40; 5.18 and 5.12 cm respectively.

Specific growth rate (SGR); Feed conversion ratio (FCR) and Protein efficiency ratio (PER):

Results of SGR as affected with protein level within each density tested show that SGR values significantly increased ($P<0.05$) in most cases with increasing protein level fed and the increases were pronounced in groups D1P4; D2P4; D3P4 and D4P4 which fed on the highest protein levels within all densities studied. Averages SGR as affected with protein level fed, regardless of stocking density were 0.80; 0.93; 1.00 and 1.05 for protein levels fed p1; p2; p3 and p4 respectively (Table 4). The statistical evaluation of results indicate that SGR increased in a significant order with each increase in protein level fed. These results support thóse of Vila and Arielt (1982), De Silva and Perera (1985), Wang *et al.* (1985) and Siddiqui *et al.* (1988). Also, Teshima and

Kanazawa (1985) who reported that Nile Tilapia fingerlings grew optimally on diets containing about 35% protein in a casein – gelatin (3:1) diet.

Results of SGR grand means as affected with the stoking density showed that the density of 80 and 100 Fish/ m^3 did not release any significant effect on this trait, however, SGR of tilapia decreased significantly ($p < 0.05$) as the density of fish increased to 120 or 140 Fish/m^3. Results of SGR as affected with stocking density are matching with those obtained for body weight and length, where stocking density over 100 fish/m^3 caused significant ($p < 0.05$) influences on their growth traits. These results are in accordance with the findings of Van der Lingen (1959 b); Chen (1969); Huet (1972); Payne (1975); Balarin (1979) and Muir and Roberts (1982); who showed that growth performance of Nile Tilapia decreased with increasing stocking density of fish. Also, Abdel. Hakim *et al.* (1995) reported that SGR values of Nile Tilapia stocked in earthen ponds at densities of 3000; 4500 and 6000 fish/ feddan were 1.35; 1.35 and respectively. The results of the same authors indicated that SGR of Nile Tilapia decreased when the stocking density exceeds 4500 fish/feddan.

Results of feed conversion ratio (FCR) illustrated in table 4 show that within each stocking density tested, increasing the dietary protein level in Nile Tilapia diets resulted in significant ($p < 0.05$) improvements in FCR in most cases and the improvement was more pronounced at lower stocking density. As presented in Table 4, averages of SGR as affected with protein level fed for the groups receiving 28 and 32% protein level were significantly ($p< 0.05$) better compared to those fed on 20 and 24% protein levels. These results are in agreement with Siddiqui *et al.* (1988), who showed that less efficient feed conversion ratios (higher values) were obtained at protein levels higher or lower than 30%

for young Tilapia. Also, Ali (1991) showed that the best feed conversion ratio was obtained by Nile Tilapia fed on diets containing 30% crude protein compared with those obtained using diets with 25; 35 or 40 % protein. Averages of (SGR) grand means as affected with stocking density, regardless of protein level fed were significantly ($p < 0.05$) better for densities 80 and 100 (D1 and D2) compared to that of higher densities 120 and 140 fish/m^3 (D3 and D4) indicating that Nile Tilapia convert the feed more efficiently when stocked in cages at lower density than at higher ones. Accordingly, a decreased growth rate with increasing density may be attributed to reduced feed consumption and higher FCR values (Vijayan and Leatherland, 1988), crowdness and reduced living space that leads to fish disturbance during feeding and normal activities (Coche, 1977), increased energy- demanding activity levels connected with social interaction (Fenderson and Carpenter, 1971; Li and Brocksen,1977), and / or suppression of growth in sub- ordinates by intimidation (Wirtz,1974).

Results of protein efficiency ratio calculated as weight gain / protein intake indicate a significant ($p < 0.05$) decrease in PER values with increasing the dietary protein levels in most cases of protein levels tested within all stocking densities (Table 4). Regardless of stocking density, averages of PER for groups fed on diets containing 20; 24; 28 and 32 % protein were 1.7; 1.6; 1.4 and 1.3g protein for each gram gain in live weight respectively and differences due to protein level among treatments were significant ($p < 0.05$) Table 4. These results indicate in general that PER of tilapia cultured in cages decreased almost in linear manner with each increase in protein level fed. The decreases in PER values with each increase in protein level fed may be explained by the fact that fish fed on lower protein levels are more efficient to utilize the protein than those fed on higher protein levels. These results are not in agreement with findings of Ali (1991) who showed that PER of Nile Tilapia increased with each increase in the protein level fed from 25 to

30; 35; 40 or 45 %. Values of PER as affected with stocking density, irrespective of protein level fed (Table 4) show that the values fluctuated between 1.4 for the highest density tested (140 F/m^3) and 1.6 for the stocking density of 100 F/m^3 and differences among D4 and D1; D2 and D3 were significant. These results indicate that Tilapia stocked at a rate of 140 $Fish/m^3$ are able to utilize dietary protein in general better than those stocked at lower rates. These results agree with the findings of Shahat (1991), who reported that PER values of Nile Tilapia stocked at rates 2Tilapia (2T) + 2cat fish (2c) ; 2T + 1c ; and 4T + 1 c/m^3 in earthen ponds were 1.91; 2.35 and 2.35, respectively indicating an improvement in PER with increasing stocking density .

Total Yield

Results of Tilapia total yield fish at harvest in kg (6 months after experimental start) are presented in Table (5). These results revealed that within each stocking density studied increasing the dietary protein level fed increased the total fish yield per cage. The grand means of total yield for the effect of protein level fed regardless of stoking density for protein levels 20; 24; 28 and 32% were 143; 18.4; 20.9 and 22.7 kg/m^3, respectively. These Results may indicate that the optimum protein level for Nile Tilapia reared in cages lies between 28 to 32%. These results are in agreement with those obtained by Grophen (1980); Guerrero (1980) and Janncey (1982), who showed that growth of Nile Tilapia increased with increasing the protein contents of the diet. Also, Osman (1988) reported that the best growth performance and consequently yield of Nile Tilapia was obtained throughout 27 weeks experimental period using diets containing 30 % protein rather than diets containing 20; 25; 35 or 40% protein levels.

As illustrated in table 5, averages of Tilapia total yield as affected with stocking density within each protein level fed increased in linear manner with each increase in the stoking density of fish.

In general these results indicate that the maximum yield occurred at the highest density (140 fish/ m^3) but at the expense of individual mean weight. Regardless of protein level fed, averages of total yield at harvesting as affected with stocking density were 15.2; 18.7; 20.8 and 21.5 kg/m^3 and the corresponding final men weights were 191.1; 187.8; 174.1 and 153.7 g, for stocking densities 80; 100; 120 and 140 fish/m^3 respectively (Table 5). These results indicate that stocking density did positively affect the production levels, but consequently the mean fish size of the harvested fish decreased, although not in a strictly proportional relationship. Increasing the density of Nile Tilapia from 80 to 100 fish/m^3 resulted in a 23% increase in the production level, while an additional 20 fish/m^3 (20%) increase in the density from 120 to 140 fish/m^3 produced only a 13.8% increase in the total yield. As observed before, harvest size of fish was significantly influenced by stocking density with the more marketable fish size, being produced at lower densities i.e. 100 and fish/m^3. Therefore, results of Table 5 suggest that stocking of Nile Tilapia fingerlings at lower densities (80 or 100 fish/m^3) may have an economic advantage over higher densities when fattening period is limited to 6 months. These results are in accordance with the findings of Adel- Hakim *et al.* (1995), who reported that total yield of Nile Tilapia cultured in earthen ponds increased with each increase in stocking density, however averages of body weights decreased in a parallel manner.

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Table 1. Composition of experimental diets of Nile Tilapia.

Ingredients	Kg per 100 kg of diet			
	Protein levels %			
	20	24	28	32
Corn yellow	36	25	26	16
Wheat bran	20	18	11	12
Rice	14	17	12	13
Soybean	6	10	13	13
Decorticated cotton Seed meal	11	13	15	15
Fish meal	5	7	10	15
poultry slaughter by- products	5	7	10	13
Vitamin premix (a)	1.5	1.5	1.5	1.5
Mineral mixture (b)	1.5	1.5	1.5	1.5
Total	100	100	100	100
Nutrient contents determined				
Crude protein %	20.089	24.098	28.109	32.071
Ether extract %	5.943	6.577	6.632	6.835
Crude fibers %	6.455	6.675	5.968	5.967
Ash %	6.067	6.984	7.397	8.873
Nitrogen free extract NFE*%	51.243	45.619	41.918	36.635
Moisture %	10.203	10.047	9.976	9.618
Total	100	100	100	100
Gross energy Kcal/Kg Diet	3198	3236	3292	3303

a) Each gram of vitamin premix contains 20.000 IU vit. A 2000 IU vit. D3, 400 vit E, 20 mg Niacin, 4.5mg riboflavin, 3 mg pyridoxine, 0.013 mg vit. B12, 100 mg Choline Chloride and 2 mg vit K.

b) Each gram contains 0.83 Ca, 0.63 P, 0.78 Na, 0.018 Mn, 0.011 Zn and 0.001 Cu. The Mixture was prepared by mixing 35 parts of dicalcium phosphate, 3 parts of mineral premix And 2 part of common salt.

*Calculated by differences.

Table 2. Effect of stocking density and protein level on final body weights of Nile Tilapia reared in cages.

Stocking density / Protein level	D1		D2		D3		D4		Grand mean	%
	Initial	Final	In.	Fin.	In.	Fin.	In.	Fin.		
P1	30.3^{a}	145.0^{a}	30.1^{a}	143.8^{a}	30.2^{a}	125.6^{a}	30.2^{a}	125.6^{a}	132.5^{a}	100
P2	30.2^{a}	183.7^{b}	30.3^{a}	180.6^{b}	30.1^{a}	170.9^{b}	30.1^{a}	170.9^{b}	170.6^{b}	128.7
P3	30.2^{a}	205.6^{c}	30.3^{a}	209.8^{c}	30.2^{a}	187.3^{c}	30.2^{a}	187.3^{c}	193.2^{c}	145.8
P4	30.1^{a}	230.3^{d}	30.2^{a}	217.3^{d}	30.2^{a}	212.7^{d}	30.2^{a}	212.7^{d}	270.6^{d}	158.9
Grand mean for density	30.2	191.2^{a}	30.2	187.8^{b}	30.18	174.0^{c}	30.18	153.8^{d}		
% Chang due to density		129.2		122.1		113.1		100		

- Averages within the same column having the same superscript do not differ significantly (p> 0.05) other wise they do
- Grandmeans for density effect within the same row and having the same superscripts do not differ significantly (P>0.05) otherwise they do.

Table 3. Effect of stocking density and protein level on final body length of Nile Tilapia reared in cages

Stocking density / Protein level	D1*		D2*		D3*		D4*		Grand * mean	
	Initial	Final	In.	Fin.	In.	Fin.	In.	Fin.	In.	Final
P1	11.5^{c}	19.8^{b}	11.5^{a}	20.0^{c}	11.5^{a}	18.9^{d}	11.3^{a}	18.5^{d}	11.45	19.3^{d}
P2	11.4^{a}	20.8^{b}	11.5^{a}	20.7^{b}	11.4^{a}	20.6^{c}	11.2^{a}	19.6^{c}	11.37	20.4^{c}
P3	11.4^{a}	20.9^{b}	11.4^{a}	21.0^{a}	11.4^{a}	21.1^{b}	11.3^{a}	20.3^{b}	11.37	20.8^{abc}
P4	11.6^{a}	21.9^{a}	11.5^{a}	21.1^{a}	11.3^{a}	21.5^{a}	11.3^{a}	20.7^{a}	11.42	21.3^{a}
Grandmean ** for density		20.8^{a}		20.7^{a}		20.5^{a}		19.8^{b}		20.4

- Averages within the column having the same suerscribte do not differ significantly (p>0.05) otherwise they do

** Grandmeans for density effect within the last row having the same superscripts do not differ significantly (p> 0.05)

Otherwise they do.

Table 4. Effect of stocking density and protein level on specific growth rate (SGR); feed conversion ratio (FCR) and protein efficiency ratio (PFR) of Nile Tilapia.

Stocking density / Protein level	D1*	D2*	D3*	D4*	Grand * mean
SGR P1	0.85^c	0.85^d	0.77^a	0.72^c	0.80^d
P2	0.98^b	0.97^c	0.94^c	0.86^b	0.93^c
P3	1.04^a	1.05^b	0.99^b	0.95^a	1.00^b
P4	1.10^a	1.07^a	1.06^a	0.97^a	1.05^a
Grandmean ** for denisty	0.99^a	0.98^a	0.94^b	0.87^c	0.94
FCR P1	2.6^a	2.5^a	2.7^a	2.9d	2.7^a
P2	2.3^b	2.3^b	2.3^b	2.6^b	2.4^a
P3	2.2^c	2.1^c	2.3^b	2.3^c	2.2^b
P4	2.1^c	2.1^c	2.1^c	2.3^c	2.2^b
Grandmean **	2.3^a	2.3^a	2.4^b	2.6^c	2.4
PER P1	1.7^a	1.8^a	1.6^a	1.5^a	1.7^a
P2	1.6^a	1.6^b	1.6^a	1.4^a	1.6^a
P3	1.5^b	1.5^c	1.4^b	1.3^b	1.4^b
P4	1.3^c	1.3^d	1.3^c	1.2^c	1.3^c
Grandmean **	1.5^a	1.6^a	1.5^d	1.4^b	1.5

A,b,c means in the same column bearing different letter differ significantly ($p < 0.05$) .

** grand means in the same row having different superscript letters differ significantly ($p< 0.05$) .