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Highlights

- Fish Growth Evaluation
- Hazardous Chemicals Effect
- Biopesticides of Weeds
- Role of Hydrogen Cyanide

Discovering Thoughts, Inventing Future

VOLUME 14 ISSUE 6 VERSION 1.0

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Fish Growth Evaluation using a One Step Numerical Algorithm for a Sustainable Development in the Third World Nations

By Enoch, O. O. & Ajenifuja, O. A.
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Abstract- We examined fishery as a supplementary source of protein for bridging the gaps created by the birds 'saga in meeting the need for protein in less developed countries. A one step algorithm is proposed, implemented on von Bertalanffy and on seasonal growth models for the evaluation of the desired enhancement in fish growth. Precautionary measure is presented against the use of poultry wastes as a component commonly used in the formulation of fishery feeds. The one-step method gives an enhanced projection in fish growth and also predicts the appropriate proportion of all other constant parameters that will be needed.

Keywords: fish growth, one-step method, bird, convergence,' consistency and stability.

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Fish Growth Evaluation using a One Step Numerical Algorithm for a Sustainable Development in the Third World Nations

Enoch, O. O. [α] & Ajenifuja, O. A.[σ]

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Keywords: fish growth, one-step method, bird, convergence,' consistency and stability.

I. Introduction

The recent pandemic on avian-influenza has brought about a great challenge to a major source of protein supply, since poultry birds have served as means of protein provider over the decades. The gap created by this pandemic must be bridged by sourcing for protein from other sources like fishery, etc. Our concern is that if fishery would serve as an alternative source of protein, what considerable input must we give into it? And at what rate must some constant conditions and variable conditions be observed and maintained for the gap in protein need to be quickly and remarkably bridged at an optimal economic state?

II. One-Step Methods Based on Non-Linear Polynomial Interpolant

In this paper, we shall examine the initial value problem of the form;

$$y^1(x) = (x, y), y(a) = y_o, \quad x \in [a, b], y \in R \tag{1}$$

Here we present some one-step methods for the solution of equation (I).

This type of construction was first reported in Fatunla (1976). The resulting method is particularly well ution. For our construction, Firstly, we assume that over the interval $\{x_t, x_{t+1}\}$, the theoretical solution, y(x), to the initial value problem (1) is given by the non-polynomial;

$$f(x) = a_1 e^x + x_t^2 \tag{2}$$

Where a, is an undetermined co-efficient. Let us consider the non-polynomial interpolant at the points $x = x_t$ and $x = x_{t-1}$ and also take the numerical estimate to the theoretical solution $y(x_t)$ to be y_t. We shall by this assumptions have;

$$f(x_t) = a_1 e^{x_t} + x_t^2 \tag{3}$$

Let $y^1(x_t) = f_t(x_t, y_t)$. For us to be able to determine the undetermined co-efficient a_1, we are to impose the assumptions that the non-linear polynomial interpolant (4) coincides with y_t and (3) coincides with y_{t-1} and y_n is a numerical estimate to the theoretical solution $y(x_n)$ and $f_n = f(x_n, y_n)$ with the mesh-point defined by $x_n = a + nh, \quad n = 0, 1, 2, 3, \ldots$

III. Constraints

The interpolating function must coincide with the theoretical solution at $x = x_n$ and $x = x_{n+1}$, for $n \geq 0$.This condition implies that

$$f(x_t) = y_t = a_1 e^{x_t} + x_t^2 \tag{5}$$

and

$$f(x_{t+1}) = y_{t+1} = a_1 e^{x_{t+1}} + x_{t+1}^2 \tag{6}$$

We also require that the first and the second derivatives of the Interpolating function respectively coincide with the differential equation as well as its first and second derivatives with respect to *x* at $x = x_n$, where $f^{(i)}$ denotes the ith total derivatives off *(x, y)* with respect to *x*

$$f^{(1)} = f(x_t, y_t) = f_t \tag{7}$$

and

$$f^{(2)}(x_t = f(x_t, y_t) = f_t^{(1)} \tag{8}$$

Differentiating (3) with respect to *x*, we have

$$f^{(1)}(x_t) = a_1 e^{x_t} + 2x_t = f_t \tag{9}$$

and

$$f^{(2)}(x_t) = a_1 e^{x_t} + 2 = f_t^{(1)} \tag{10}$$

Solving for a_1 from equation (10), we have

$$a_1 e^{x_t} + 2 = f_t^{(1)}$$

$$a_1 e^{x_t} + 2 = f_t^{(1)} - 2$$

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$$a_1 = \frac{f_t^{(1)} - 2}{e^{x_t}}$$

From (6) and (5), we have

$$f(x_{t+1}) - f(x_t) = y_{t+1} - y_t \tag{12}$$

This implies that

$$y_{t+1} - y_t = a_1 e^{x_{t+1}} - a_1 e^{x_t} + x_{t+1}^2 - x_t^2$$
$$= a_1(e^{x_{t+1}} - e) + (x_{t+1}^2 - x_t^2) \tag{13}$$

Recall that;

$$x_t = a + th, \; t = 0, 1, 2, 3, \tag{14}$$

and

$$x_{t+1} = a + (t+1)h \Rightarrow a + th + h \Rightarrow x_t + h$$

therefore

$$x_{t+1} = a + (t+1)h \Rightarrow a + th + h \Rightarrow x_t + h,$$

and

$$x_{t+1}^2 = (x_t + h)^2 \Rightarrow (x_t + h)(x_t + h) \tag{15}$$
$$= x_t^2 + 2x_t h + h^2 \tag{16}$$

Let us put (11) and (16) into (13) to obtain

$$y_{t+1} - y_t = \frac{f_t^{(1)} - 2}{e^{x_t}}(e^{x_{t+1}} - e^{x_t}) + (x_t^2 + 2x_t h + h^2 - x_t^2$$

$$y_{t+1} - y_t = \frac{f_t^{(1)} - 2}{e^{x_t}}(e^{x_{t+1}} - e^{x_t}) + (2x_t h + h^2)$$

Thus the above numerical scheme can be written in the form

$$y_{t+1} = y_t + [f_t^{(1)} - 2](e^h - 1) + h(2x_t + h) \tag{17}$$

Equation (17) is a one-step method that can be used to solve equation of the form (1) .Equation (17) can be regarded as a numerical integration scheme which is particularly well suited to initial value problems havingoscillatory and exponential solutions and it was first reported and implemented in Fatunla (1976).

IV. Prove of Convergence for the New Scheme

According to Henrici (1962): we define any algorithm for solving a differential equation in which the approximation y_{t+1} to the x_{t+1} solution at the x_{t+1} can be calculated if only x_t, y_t and h are known as a ONE-STEP METHOD. We proceed to establish that our numerical algorithms are one step methods. From $F(x_t) = a_1 e^{x_t} + x_t^2$; the numerical integrator generated is given by

$$y_{t+1} = y_t + (f_t^{(1)} - 2)(e^h - 1) + h(2x_t + h),$$

If we expand eh, we shall have

$$e^h = \sum_{r=0}^{\infty} \frac{(-1)^r h^r}{r!} = 1 - h + h^2/2! - h^3/3! + \ldots \tag{18}$$

This implies

$$y_{t+1} = y_t + (f_t^{(1)} - 2)(x - h + h^2/2! - h^3/3! + \ldots - 1) + h(2x_t + h) \tag{19}$$

$$y_{t+1} = y_t + (f_t^{(1)} - 2)(-h + h^2/2! - h^3/3! + \ldots) + h(2x_t + h) \tag{20}$$

$$y_{t+1} = y_t + h(f_t^{(1)} - 2)(-h + h^2/2! - h^3/3! + \ldots) + h(2x_t + h) \tag{21}$$

Let A $= (-1 + h^2/2! - h^3/3! + \ldots)$ and B $= (2x_t + h)$, We shall have, $y_{t+1} = y_t + h[(f_t^{(1)} - 2)A + B]$

This is the convergence of the first scheme;

$$y_{t+1} = y_t + h\{(f_t^{(1)} - 2)c - 1 + h/2! - h^2/3! + \ldots) + (2x_t + h)\} \tag{22}$$

which can be written as $y_{t+1} = y_t + h(f_t^{(1)} - 2A + B)$, we have been able to write it in the form $y_{t+1} = y_t + h\phi(x_t, y_t; h)$, for which $h\phi(x_t, y_t; h) = (f_t^{(1)} - 2A + B)$.

V. Definition: Henrici (1962)

We define any algorithm for solving a differential equation in which the approximation y_{t+1} to the solution at the point X_{t+1} can be calculated, if only X_t, Y_t and h are known, as a ONE-STEP METHOD. It is a common practice to write the functional dependence, y_{t+1}, on the quantities X_t, Y_t and h in the form.

$$y_{t+1} = y_t + h\Phi(x_t, y_t; h.$$

VI. Convergence

THEOREM 1: Given a differential equation of the form $y^1 = f(x, y)$, $y(a) = ℓ$, let $f(x, y)$ be defined and continuous for all points (x, y) in the region Dom, defined by $a \le x \le y$, $-\infty \le y \le \infty$,a and b finite, and let there exist a constant 1 such that for every x, y^*, y with (x, y) and (x, y^*) both in Dom

$$|f(x, y) - f(x, y^*)| \le L|y - y^*|, \tag{23}$$

and ℓ is any given number, there exist a unique solution y(x) of the initial value problem. The inequality (23) is known as a Lipschitz condition and the constant L as a Lipschitz constant. This condition can be regarded as being intermediate between differentiability and continuity, in the sense that if $F(x, y)$ in Dom, this implies that $F(x, y)$ satisfies a Lipschitz condition with respect to y for all (x, y) in Dom. (Fatunla, 1988; Lambert, 1973a; and Ibijola, 1998). By the mean value theorem, F(x, y) possessing a continuous derivative with respect to y for all (x, y) in Dom, will imply that;

$$f(x,y)-f(x,y^*)=\frac{\partial f(x,\overline{y})}{\partial y}(y-y^*). \quad (24)$$

it follow that (24) can now be satisfied if we choose

$$L=\sup\frac{\partial f(x,\overline{y}),}{\delta y} then,$$

$$y_{t+1}=y_t+h\{Af_t^{(1)}-2A+B\}$$

$$\phi(x_t,y_t;h)=Af^{(1)}_{(x_t,y_t)}-2A+B$$

$$\phi(x_t,y_t^*;h)=Af^{(1)}_{(x_t,y_t^*)}-2A+B$$

Hence

$$\phi(x_t,y_t^*;h)-\phi(x_t,y_t;h)=A(f^{(1)}_{(x_t,y_t^*)}-f^{(1)}_{(x_t,y_t)})-2A+2A-B+B \quad (25)$$

$$\phi(x_t,y_t^*;h)-\phi(x_t,y_t;h)=A(f^{(1)}_{(x_t,y_t^*)}-f^{(1)}_{(x_t,y_t)}) \quad (26)$$

let $\overline{y_t}$ be defined as a point in the interior of the interval whose endpoints are y and y*, by applying the mean value, we have;

$$f^{(1)}_{(x_t,y_t^*)}-f^{(1)}_{(x_t,y_t)}=\frac{\partial f^{(1)}_{(x_t\ ,\ \overline{y}_t^*)}}{\partial y_t}(\,y_t^{(*)}-y_t) \quad (27)$$

let$L_1=sup\frac{\partial f^{(1)}_{(x_t\ ,\ y_t)}}{\partial y_t}$. Substitute (27) into (26)

$$\phi(x_t\ ,\ y_t^*\,;h)-\phi(x_t\ ,y_t\ ;h)=A\left[\frac{\partial f^{(1)}_{(x_t\ ,\ \overline{y}_t^*)}}{\partial y_t}(\,y_t^{(*)}-y_t)\right]$$

$$=A\ sup\ \frac{\partial f^{(1)}_{(x_t\ ,\ \overline{y}_t)}}{\partial y_t} \quad (28)$$

$$(x_t\ \ ,\ \ \overline{y}_t)\varepsilon\ Dom$$

$$\phi(x_t\ ,\ y_t^*\,;h)-\phi(x_t\ ,y_t\ ;h)=AL_1(y_t^*-y_t) \quad (29)$$

Taking the absolute value of both sides of (29), we have

$$|\phi(x_t\ ,\ y_t^*\,;h)-\phi(x_t\ ,y_t\ ;h)|\leq|Al_1||y_t^*-y_t|$$

$$|\phi(x_t\ ,\ y_t^*\,;h)-\phi(x_t\ ,y_t\ ;h)|\leq\ L|y_t^*-y_t| \quad (30)$$

VII. Numerical Experiments

a) Von Bertalanffy fish growth

The differential equation presented below is the model on the von Bertalanffy fish growth; $dy/dx=\alpha y^{2/3}-\beta y, y(0)=2$ and its theoretical solution is given as$y=1/(\alpha/\beta+Ae^{-\beta x/2})^2$, where $y = y(x)$ is the weight of the fish, α and β are positive constants. We determine and illustrate the predicted growth of a fish, using the new numerical methods.

(i) H = .01: α = .95: R1 = .5: β = 2

This is the Numerical Result on Model for von Bertalanffy Fish Growth

X(T)	Y(X(T))	FY(T+1)	TFNUME
0.000000	2.000000	1.979900	0.020100
0.010000	2.019090	1.997950	0.021141
0.020000	2.038363	2.015636	0.022727
0.030000	2.057818	2.032856	0.024962
0.040000	2.077457	2.049607	0.027850
0.050000	2.097282	2.065888	0.031394
0.060000	2.117294	2.081698	0.035595
0.070000	2.137493	2.097036	0.040457
0.080000	2.157881	2.111901	0.045981
0.090000	2.178460	2.126292	0.052168
0.100000	2.199231	2.140212	0.059019

For convergence y (0) must be equal to β: convergency is guaranteed for 0.001<h<0.01.

(ii) H = .01: α = .901: Y' = R1*Y(T)^3/2-R2*Y(T), Y(0) = 2: R1 = .72: β = 4

This is the Numerical Result on Model for von Bertalanffy Fish Growth

X(T)	Y(X(T))	Y(T+1)	Truncation Error
0.000000	4.000000	3.979900	0.020100
0.010000	4.036202	4.012372	0.023830
0.020000	4.072731	4.044457	0.028274
0.030000	4.109586	4.076072	0.033514
0.040000	4.146769	4.107234	0.039535
0.050000	4.184280	4.137961	0.046319
0.060000	4.222121	4.168275	0.053846
0.070000	4.260292	4.198195	0.062098
0.080000	4.298794	4.227743	0.071051
0.090000	4.337628	4.256942	0.080686
0.100000	4.376794	4.285816	0.090978

For convergence y(0) must be equal to β: convergency is guaranteed for 0.001<h<0.01.

(iii) H = .001: α = .8: Y' = R1*Y(T)ˆ3/2-R2*Y(T), Y(0) = 2: R1 = .72: β = 4

This is the Numerical Result on Model for von Bertalanffy Fish Growth

X(T)	Y(X(T))	Y(T+1)	Truncation Error
0.000000	4.000000	3.997999	0.002001
0.010000	4.003201	4.000559	0.031569
0.020000	4.006405	4.003116	0.061397
0.030000	4.009612	4.005669	0.091485
0.040000	4.012821	4.008217	0.121834
0.050000	4.016032	4.010762	0.152445
0.060000	4.019246	4.013302	0.183318
0.070000	4.022463	4.015838	0.214452
0.080000	4.025682	4.018370	0.245849
0.090000	4.028904	4.020898	0.277507
0.100000	4.032128	4.023422	0.309427

For convergence y(0) must be equal to β: convergency is guaranteed for 0.001<h<0.01

(iv) H = .001: α = .9: Y' = R1*Y(T)ˆ3/2-R2*Y(T), Y(0) = 2: R1 = .72: β = 2

This is the Numerical Result on Model for von Bertalanffy Fish Growth

X(T)	Y(X(T))	Y(T+1)	Truncation Error
0.000000	2.000000	1.997999	0.002001
0.010000	2.001801	1.999619	0.002182
0.020000	2.003603	2.001237	0.002367
0.030000	2.005407	2.002851	0.002557
0.040000	2.007213	2.004461	0.002752
0.050000	2.009020	2.006068	0.002952
0.060000	2.010829	2.007672	0.003157
0.070000	2.012640	2.009272	0.003368
0.080000	2.014452	2.010869	0.003583
0.090000	2.016266	2.012462	0.003803
0.100000	2.018081	2.014052	0.004029

For convergence y(0) must be equal to β: convergency is guaranteed for 0.001<h<0.01.

b) *Seasonal Growth*

The model on seasonal growth is given by $dy/dx = r\,x\cos(wx), y(0) = 2$ where r and w are constants. In this work, we illustrate the behavior of the numerical solution of this equation. The theoretical solution is $y = Ke^{r\sin(wx)/w}$

(i) H = .01: r = .95: R1 = .5: W = 2

This is the Numerical Result on Model for Seasonal Growth

X(T)	Y(X(T))	Y(T+1)	Truncation Error
0.000000	2.000000	1.980000	0.020000
0.010000	2.019090	1.998250	0.020841
0.020000	2.038363	2.016236	0.022127
0.030000	2.057818	2.033956	0.023862
0.040000	2.077457	2.051407	0.026050
0.050000	2.097282	2.068588	0.028693
0.060000	2.117294	2.085498	0.031795
0.070000	2.137493	2.102136	0.035357
0.080000	2.157881	2.118500	0.039381
0.090000	2.178460	2.134592	0.043868
0.100000	2.199231	2.150412	0.048819

For convergence y(0) must be equal to w: convergency is guaranteed for 0.001<h<0.01.

(ii) H = .01: r = .98: Y' = gycosx'y(0) = 3: R1 = .5: W = 3

This is the Numerical Result on Model for Seasonal Growth

X(T)	Y(X(T))	Y(T+1)	Truncation Error
0.000000	3.000000	2.980000	-0.288753
0.010000	3.029544	3.009012	-0.291186
0.020000	3.059379	3.037595	-0.292856
0.030000	3.089506	3.065744	-0.293754
0.040000	3.119927	3.093454	-0.293875
0.050000	3.150645	3.120721	-0.293209
0.060000	3.181661	3.147542	-0.291753
0.070000	3.212978	3.173913	-0.289501
0.080000	3.244598	3.199832	-0.286447
0.090000	3.276522	3.225298	-0.282590
0.100000	3.308753	3.250311	-0.277925

For convergence y(0) must be equal to w: convergency is guaranteed for 0.001<h<0.01 and .9<r<1.0.

(iii) H = .001: r = .89: R1 = .5: W = 2

This is the Numerical Result on Model for Seasonal Growth

X(T)	Y(X(T))	Y(T+1)	Truncation Error
0.000000	2.000000	2.002002	-0.002002
0.010000	2.001781	2.003588	-0.001807
0.020000	2.003563	2.005172	-0.001609
0.030000	2.005347	2.006754	-0.001407
0.040000	2.007133	2.008334	-0.001201
0.050000	2.008920	2.009911	-0.000991
0.060000	2.010709	2.011486	-0.000777
0.070000	2.012499	2.013059	-0.000560
0.080000	2.014291	2.014629	-0.000338
0.090000	2.016084	2.016197	-0.000113
0.100000	2.017879	2.017764	-0.000116

For convergence y(0) must be equal to w: convergency is guaranteed for 0.001<h<0.01 and .9<r<1.0.

(iv) H = .001: r = .89: R1 = .5: W = 2

This is the Numerical Result on Model for Seasonal Growth

X(T)	Y(X(T))	Y(T+1)	Truncation Error
0.000000	1.000000	0.998000	0.002000
0.010000	1.001001	0.999002	0.001998
0.020000	1.002002	1.000002	0.002000
0.030000	1.003005	1.001000	0.002005
0.040000	1.004008	1.001996	0.002012
0.050000	1.005013	1.002990	0.002022
0.060000	1.006018	1.003982	0.002036
0.070000	1.007025	1.004972	0.002052
0.080000	1.008032	1.005960	0.002072
0.090000	1.009041	1.006946	0.002094
0.100000	1.010050	1.007930	0.002120

For convergence y (0) must be equal to w: convergency is guaranteed for 0.001<h<0.01.

(v) H = .01: r = .95: R1 = .5: W = 1

This is the Numerical Result on Model for Seasonal Growth

X(T)	Y(X(T))	Y(T+1)	Truncation Error
0.000000	1.000000	0.980000	0.020000
0.010000	1.009545	0.989225	0.020321
0.020000	1.019181	1.998318	0.020864
0.030000	1.028909	1.007278	0.021631
0.040000	1.038729	1.016103	0.022625
0.050000	1.048641	1.024794	0.023847
0.060000	1.058647	1.033349	0.025298
0.070000	1.068746	1.041768	0.026979
0.080000	1.078941	1.050050	0.028891
0.090000	1.089230	1.058196	0.031034
0.100000	1.099615	1.066206	0.033410

For convergence y(0) must be equal to w: convergency is guaranteed for 0.001<h<0.01.

VIII. Data Interpretation and Conclusion

This presents to us that the fishes grow in sizes, with H being the interval of feed input and r, R1 and w being the aeration, rate of picking and feed quality.

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These days it is not scientifically right to use poultry waste in the composition of feed in fishery since this could further enhance the spread of avian-influenza through fish to men. Economically, if the figures presented above are measured in hundreds, the growth rate will favour the third world countries and help in increasing the quantity of fish supply in these countries. This will also serve as a means of bridging the gaps in protein deficiency created by the bird flu saga in the less developing nations.

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Trends in the *Chamelea Gallina* Production from Molise Region (Adriatic Sea, Italy): A Ten-Year Survey

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Abstract- This study provides a qualitative and quantitative assessment of Chamelea gallina stock in the italian region Molise (Adriatic Sea) in 2003-2012 years. We investigated abundance, biomass and size distr ibution of Clams populations. Reported results showed biomass and abundance fluctuations in several years and at different investigated areas. The areas with greater fishable biomass are those near Trigno and Rio Vivo rivers, especially in 2010- 2012 years. In Both areas, the Clams biomass and density amounts show strong seasonal and annual variations with no detectable seasonal equal trends in several years. In this study, concentrations of sub-commercial size individuals suggesting crowded conditions were never detected. Data analysis also evidence that fishery activity is based almost exclusively on specimens that have just reached minimum commercial size (25-35 mm). However, in both areas, there was a progressive increase in commercial Organisms size; so it is supposable, despite recruitment low rate, a positive trend for population growth.

Keywords: chamelea gallina, bivalves, size distribution, resource's management, adriatic sea.

GJSFR-D Classification : *FOR Code: 079999*

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Strictly as per the compliance and regulations of :

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I. Introduction

The striped venus clam *Chamelea gallina* is a bivalve, lamellibranch, filter feeder belonging to the Veneridae family; it lives in high beds density hosting the "biocenosis of fine well-sorted sands" (SFBC) as described by Peres & Picard (1964), at depths between 1 and 15 m. It is particularly present in the wild, mainly on the central and northern Adriatic, where the sea water is rich in mineral salts and organic matter, due to inputs of rivers like Po and others. The target species is gonocorist with a spawning season approximately comprised between April and October with 1-2 peak(s) (FROGLIA, 1975 a, b; CASALI, 1984; VALLI *et al.*, 1985; KELLER *et al.,* 2002). The earliest mature individuals are 13-15 mm (MARANO *et al.,* 1982; CORDISCO *et al.,* 2003), though full maturity is reached when clams are 20-25 mm and about two years old.

In Adriatic area the clams reach a size of 15-20 mm at the beginning of the first year of life, approximately 25 mm a year later, and 32-34 mm in the third year (POGGIANI *et al*., 1973; FROGLIA, 1975a; MARANO *et al*., 1982; ARNERI *et al*., 1995). However, some studies (NOJIMA & RUSSO, 1989; MASSÈ, 1971) have shown that the growth rate of individuals can differ among sites, and age classes may have a slightly different range. Nevertheless, according to the Council Regulation (EC) No 1967/2006, 25 mm is the minimum commercial size allowed.

Studies on the ecology and physiology of *Chamelea gallina* are scarce, but some information on environmental factors influencing its abundance may be gained from several studies carried out since the mid-1970s in the northern Adriatic in response to phenomena such as "red tides", as well as "marine snow" which could negatively impact both human health and tourism (ROMANELLI *et al*., 2009).

It is known that the growth of bivalves is primarily dependent on food availability, water temperature and salinity, and sediment characteristics (BROOKS *et al*., 1991; ORBAN *et al*., 2002; ORBAN *et al*., 2004).

Chamelea gallina feeds on phytoplankton and other suspended material; for its growth the dissolved nutrients amount and the nitrogen and phosphorus ratio are also relevant.

Water temperature has a dominant role in growth rates: values below 10 °C strongly slow or avoid growth (FROGLIA, 2000), while very high temperatures measured on the sea bottom (28 ° C) during summer have detrimental effects, reducing energy absorption and above all increasing energy expenditure via respiration (RAMÓN & RICHARDSON,1992; MOSCHINO & MARIN, 2006).

Dissolved oxygen is a further abiotic factor influencing bivalves growth: hypoxia, anoxia and high temperatures during summer seasons can lead to increased ammonia concentrations which may contribute to negative growth values in exposed animals, as demonstrated in *R. decussatus* by SOBRAL & WIDDOWS (1997).

An additional source of stress for *C. gallina* is reproduction, which starts from spring and continues until late summer, with a reproductive peak in July (NOJIMA & RUSSO, 1989). *C. gallina*, similarly to many other bivalve species, shows increased respiration rates during the reproductive period (WIDDOWS, 1978; IGLESIAS & NAVARRO, 1991; URRUTIA *et al*., 1999).

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In the 1970s the development of clam fishery based on hydraulic dredges led to an over-exploitation of the resource with a dramatic decrease in density of clams populations and an increase in mortality events from the 90s onwards (Ministry of Agriculture, 1998). In the late 1970s the fishery yielded 80,000-100,000 metric tons while actually it doesn't exceed 20,000 metric tons.

At the beginning of the 80s, general rules were defined for limiting fishing licenses and establishing the maximum catches allowed in order to minimize the resource depletion.

In recent years, clam fishery management has been entrusted directly to fishermen' associations who plan fishing activity on the basis of available resources, set fishing days per week, work's daily hours, periods of catch suspension and daily catch amounts.

In the Italian region of Molise it exists a unique association named Co.Ge.Vo. and established in 1995, with ten clam vessels.This association, authorized by the Ministry of Agriculture and Forestry to manage the resource *Chamelea gallina*, has as main objective the enhancement, protection and safeguard of clam populations through the establishment of planting and restocking areas, the monitoring of catches effort, and the arrangement of periodic alternation between work and rest among fishermen.

The present study evaluates populations of *Chamelea gallina* along Molise's coastline in terms of biomass and size distribution, recruiment abundance, in order to provide useful informations for better resource management and efficient production planning by clams associations.

II. Materials and Methods

a) Study area

The Molise region is located in the center-southern area of Italy and is washed by Middle-Southern Adriatic waters. The study area extends for about 35 km of coastline and has uniform characteristics, without important inlets, except for the port of Termoli city (Molise, Italy). The sea bed is sandy and, near the major rivers' estuaries, muddy. It gently slopes up to 6-8 meters of depth, at a distance of approx. 0.3 nautical miles from the coastline. In addition, artificial reefs and breakwaters are placed along extended coastline parts at short distance from the shore.

There are four rilevant streams: Trigno, Sinarca, Biferno and Saccione (listed as located from north to the south of coastlines) and secondary streams (Tecchio, Mergolo and Rio vivo). The fluvial apports influence physical and chemical parameters of sea water: in fact rilevant changes of salinity and suspended matter are recorded near freshwater inflows. The salinity values vary on average between 22‰ and39 ‰, while those of the suspended matter between 3 mg/l and 56 mg/l. The water temperature values show seasonal fluctuations and are generally comprised between 8°C (winter) and 28 °C (summer).

b) Sampling and analyses

Clam samples were dredged along the Molise's coastline, comprised between Trigno and Saccione rivers, in 2003-2012 years at regular time intervals. Seasonal samplings were conducted according to monitoring plans approved by the Molise region and weather and sea water conditions permitting.

The survey area was divided into four zones: Trigno, Sinarca, Rio vivo e Saccione.

Sampling was carried out in collaboration with fishermen's cooperative.

The catches were performed by hydraulic dredges with 11 mm grid, along transects perpendicular to the coast at a distance of 250-500 m from coastline, dredging 200-300 m long stretches. All sampling points were located with GPS positioning system.

For each catch, all sampled material collected into the dredge was weighted and a subsample, rapresentative of total individuals, was prelevated, placed in net bags and labelled. After collection, animals were transported within about an hour to the laboratory in a cool box.

In laboratory, at first, organisms with open or damaged shell were discarded. The antero-posterior lenght (L) of the shells was measured using a 0.1 mm precision calliper, and it was defined size distribution on the basis of lenght measurements.

Popolutation distribution was assessed in respect to clams' size and age, considering three specific dimensional groups:

- 12-24 mm: group 1+, specimens of two;
- 25-35 mm: group 2+, specimens of three;
- >35 mm: group 3+, specimens over three.

In this study, the size distribution analysis was affected by the selectivity of used dredges so it was impossible to evaluate specimens in the first year of age (class 0 +). It was then recorded the weight of commercial (≥ 25 mm) and sub-commercial (<25 mm) clams and finally estimated the resource's abundance. The catches values were calculated according to the following formula: catch (Kg/1000 sqm) = clams weight (kg) * 1000 / (length of dredged stretch (m) * dredge's width (m)).

III. Results and Discussion

a) Chamelea gallina stocks evaluation

National clams production data reported by the Italian Ministry of Agriculture and Forestry (Irepa sources) for 1996-2009 years show a positive long-term trend, although the bivalves production after introduction of hydraulic dredges showed highly variable phases of expansion and contraction. During the period between 1996 and 2009, a steady decline in fishing effort determined a production reduction and a substantial stability of the catch per unit effort (CPUE). In 2005–2009 years, the values of annual production in the compartment of Termoli varied between 129,295 and 374,733 kg (Irepa sources).

In the present study, during 2003-2012 years, fishable biomass ranged in average between 3.3 and 60.9 kilogram/1000sqm in Trigno zone (Fig. 1), between 1.6 and 21.2 kilogram/1000sqm m in Sinarca zone (Fig. 2), between 6.9 and 58.3 kilogram/1000sqm in Rio vivo zone (Fig. 3), between 0.1 and 32.6 kilogram/1000sqm in Saccione zone (Fig. 4).

In all areas, biomass values of not-commercial clams are always lower than those of fishable biomass, with mean values between 1.5 and 25.8 kilogram/ 1000sqm m in Trigno area (Fig. 1), between 2.7 and 13.3 kilogram/1000sqm m in Sinarca area (Fig. 2), between 4 and 39.6 m kilogram/1000sqm in Rio vivo area (Fig. 3), between 0.04 to 9.8 kilogram/1000sqm in Saccione area (Fig. 4).

From 2008, it was evidenced a marked increase in commercial and juveniles clams' biomass values, even with large seasonal fluctuations, in all areas, except for Sinarca.

In addition to temporal variations of *Chamelea gallina* biomass, also changes in the populated surface area constitute an indication of the resource's exploitation state.

Considering the natural beds' distribution along the Molise coastline in 2003-2012 years (unpublished data), we show marked variations in the clams' areas extension, in particular a clear decrease in the southern area of Termoli. This observation emphasizes the importance of knowledge in terms of both spatial and temporal variations for the proper planning of *Chamelea gallina* management.

Data reported in this study seem to indicate that the fishing effort has been unevenly deployed over the last decade along Molise coast, but nevertheless, in most considered areas, with compatible time frame for stocks natural balance.

Considering limit value for the fishery economic sustainability as 5 kilogram/1000 sqm, analysis of the last decade data shows that Saccione area, unlike all the others, is a poorly productive area, in fact in the most sampling observations were found values close to that limit. From comparison of the biomass values recorded in different zones during last decade, it is clear that areas with greater fishable biomass are those near Trigno and Rio vivo, especially in 2010-2012 years.

Based on these evidences, we evaluated seasonal biomass trends during 2010-2012 years in the two areas mentioned above.

In Trigno zone, the highest values of fishable biomass were found in summer and autumn of 2010 and in spring of 2011 (Fig. 5). These data can be explained considering the growth of sub-commercial individuals recorded in large amounts in the spring of 2010 (Fig. 6). The importance of recruitment is also evident in terms of abundance. In fact, considering the biomass and abundance graphs in Trigno area (Fig. 5, 6, 7 and 8), these show similar seasonal trends, with the exception of spring 2012, when low biomass values corrisponding to high juveniles density. This result is explained considering the high abundance values of organisms with 20-21 mm size.

In Rio vivo area, the highest values of fishable biomass were recorded in autumn 2011 (Fig. 9). The biomass and abundance graphs showed the same seasonal trends during 2010-2012 years (Fig. 9, 10, 11 and 12).

The clams biomass and density amounts show strong seasonal and annual variations in both areas, with no detectable similar trends in several years. This data is in agreement with findings reported by Italian Ministry of Agriculture and Forestry (Irepa sources) in terms of trends in catch per unit of effort and clams' production for Molise region during period 1996-2009. These fluctuations could be due to natural resource's variations or fishery activities. During 2010-2012 years, data collected in Trigno zone, the most productive fishing area along Molise' s coastline, seem to indicate that fishing effort has been limited and has not altered the biomass availability.

b) Chamelea gallina population structure

Outcome of population analysis are given only for Trigno and Rio vivo areas because, on the basis of biomass values recorded in all zones, these areas are the most representative of Molise clams stocks.

Considering collected data during 2010-2012 period in the Trigno area, abundance values, in terms of percentage of organisms with 12-24 mm size, show large annual variations (Fig. 13), with maximum in winter 2010 (84%) and minimum in summer 2011 (26%). These trends may be due to fishing activities and also stressed that the abundance of specimens belongig to 1 + group can be a useful tool for fishery planning in next year.

On the contrary, considering abundance values in terms of percentage of organisms with 12-24 mm size in the Rio vivo area during 2010-2012 period (Fig. 14), there are no clear seasonal patterns or evident annual variations.

Comparing two areas, it is evident that in Rio vivo zone population consists of organisms with lower percentage sub-commercial size than those resident in Trigno area. Moreover Rio vivo clam population is characterized by lower variability in terms of abundance percentage and, consequently, by greater stability of community structure.

Clams' growth is influenced by several abiotic and biotic factors as well as population density. In fact, in presence of density above500 individuals/m2 (overcrowding), phenomena as natural mortality increasing have been highlighted, especially in summer when hypoxic events, lower growth rates and reduced recruitment are more frequent (BACHELET et al., 1992).

In this study, concentrations of sub-commercial size individuals suggesting crowded conditions were never detected. In conditions of not-overcrowding and in presence of high densities, to lower values of average size Correspond higher recruitment rates.

In order to assess stocks recruitment, clams size and density mean values were compared.

In Trigno area, an opposite pattern for the two indicators of recruitment importance is evident: in presence of higher densities we have smaller sizes. In contrast, in the Rio vivo area, the comparison between size and density annual average values shows no correspondence, presumably due to lower abundance values.

In Trigno area, during 2010-2012 years, average size values are comprised between 21.34 and 26.47 mm, while in Rio vivo area between 24 and 26.04 mm; these data seem to indicate a low recruitment rate in both areas.

Considering size-abundance diagrams relative to 2010 in both areas, a uniform shift towards bigger size classes at seasons following is detected (Fig. 15 and 16): this trend reflects clams natural growth. The values of modal size increase progressively from 21 mm (in fall) to 26 mm (in autumn) in Trigno area and from 23 to 25 mm in Rio vivo area.

On the contrary, in both areas, a clear seasonal pattern relative to 2011 is not detected (Fig 17 and 18). Finally, in 2012, size-abundance diagrams show same trends in all seasons with values of modal size between 24 and 25 mm in Trigno area and between 25 and 26 mm in Rio vivo area (Fig. 19 and 20).

These results show widely variable trends from year to year and indicate that populations of *Chamelea gallina* consist mainly of organisms with close to commercial size (25 mm). In fact, even considering seasonal mean values of Bodies length in both areas, in 2010-2012, these are close to commercial size (25 mm).

In addition, considering only commercial fraction, bodies average length values range between 25.9 and 27.7 mm in Trigno area and 26.3 and 27.9 mm in Rio vivo area.

Data analysis evidence that fishery activity is based almost exclusively on one age class (group 2+: 25-35 mm): specimens that have just reached minimum commercial size. In fact, clams over 35 mm are very scarce.

This finding is in agreement with previous studies showing disappearance of great size organisms compared to the past (ROMANELLI *et al*., 2009). Finally, in both areas, there is a progressive increase in commercial Organisms size. So it is supposable, despite recruitment low rate, a positive trend for population growth.

IV. Conclusions

Reported results show biomass and abundance fluctuations in several years and at different investigated areas, stressing the importance of temporal and spatial scale observations. This need is due to the high variability of coastal environment and of considered specie.

Considering temporal and spatial trends of *Chamelea gallina* in the study's initial period, a clear exploitation of natural beds with a drastic populations' decrease in some areas is highlighted.

In contrast, it is evidenced that althought during 2003-2012 years the most exploited fishing area was the Trigno zone, the applied fishing effort seemed sustainable, presumably due to management measures implemented by association (e.g. suspension of fishing activity, amounts of daily clams catch).

Total community is, however, subjected to large fluctuations in terms of abundance percentage and close to commercial size organisms are predominant. This finding emphasizes the importance of continuous monitoring plans.

In fact, although study's results point out not relevant phenomena of reduced growth or increased natural mortality, local fishing communities reported some death events during the examined period.

Considering that monitored population doesn't seem subjected to particular suffering conditions, clams beds investigation are facilitated and support subsequent comparisons in case of future anthropogenic disturbance or environmental phenomena.

It is also advisable to improve sampling and population analysis techniques through advanced tools, until now rarely used for this species in Adriatic Sea. Finally these kind of studies could be more exhaustive if implemented by outline informations.

Continual and so defined research activities are valid tools for maintaining close relationships between scientists and fisherman and for stimulating an awareness of resource conservation by fishing associations.

Monitoring plans targeted and closely related to fishermen are useful to provide real-time informations for the planning of resource management in time and space by clams sector associations. Previous research has in fact allowed Chamela gallina stocks enjoy a good stability degree on national scale in recent years, which is determined by sufficient recruitment, strong attenuation in frequency of high mortality events and adoption of more careful management practices.

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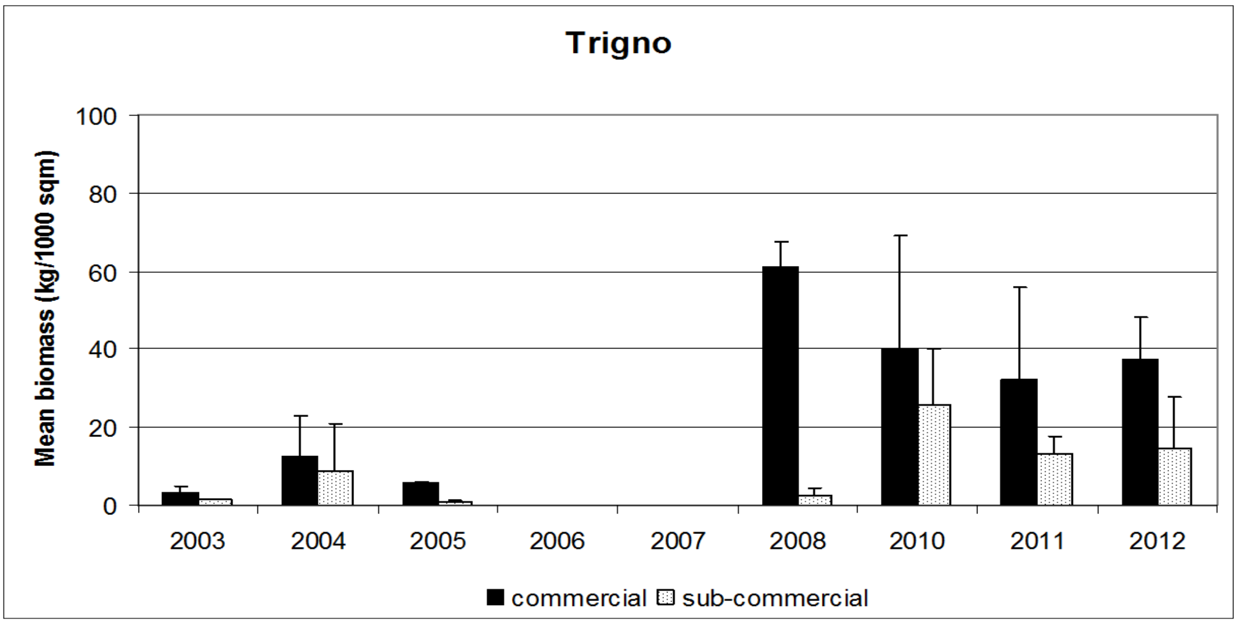

Figure 1 : Clam biomass annual variations in Trigno area during 2003-2012.

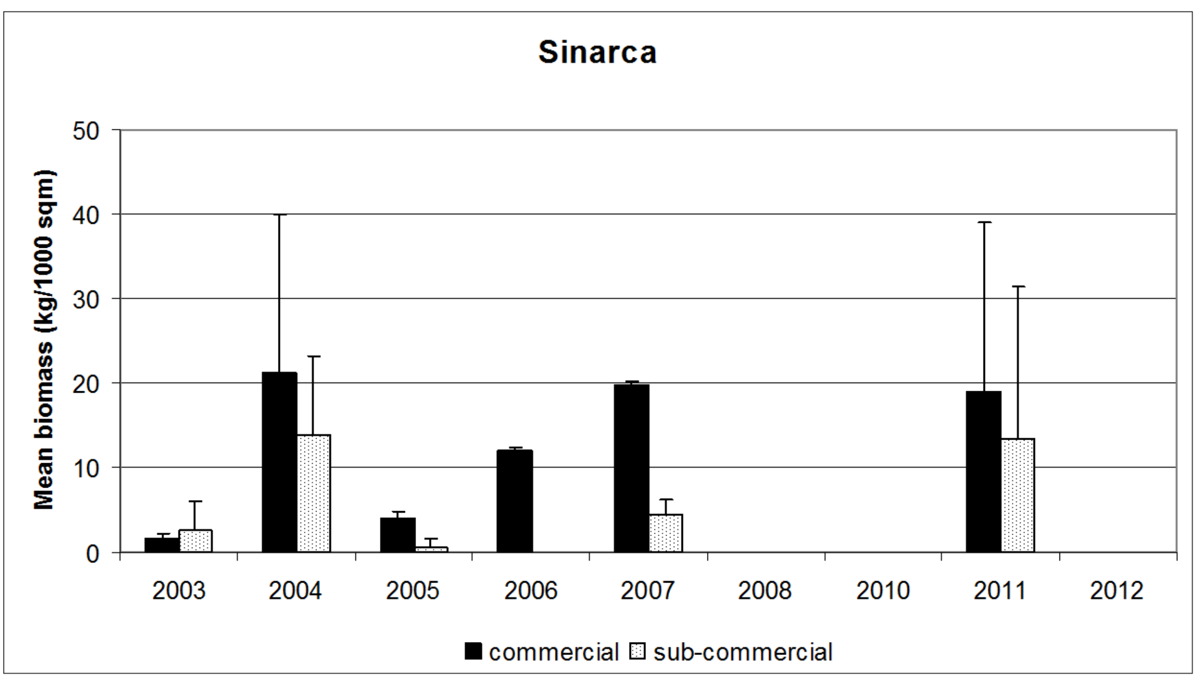

Figure 2 : Clam biomass annual variations in Sinarca area during 2003-2012.

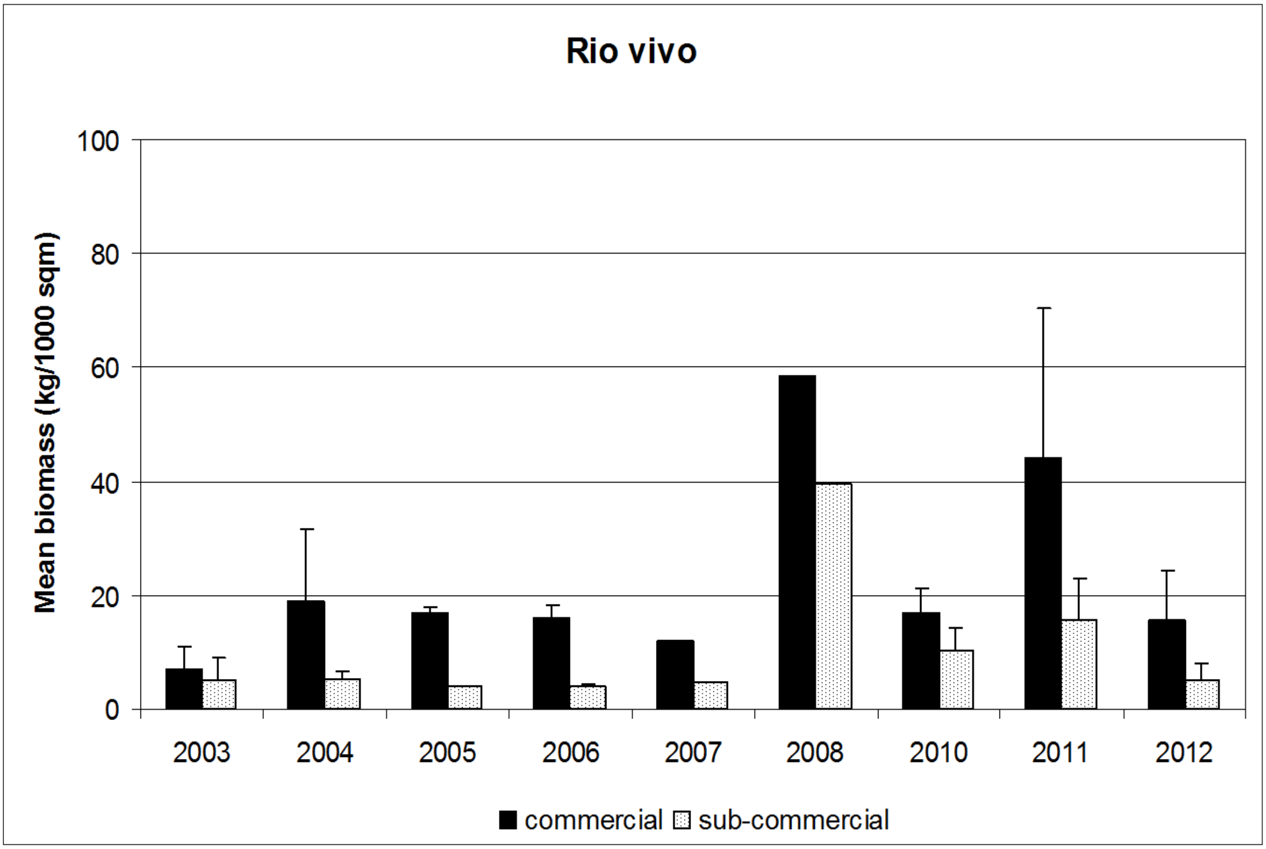

Figure 3 : Clam biomass annual variations in Rio vivo area during 2003-2012.

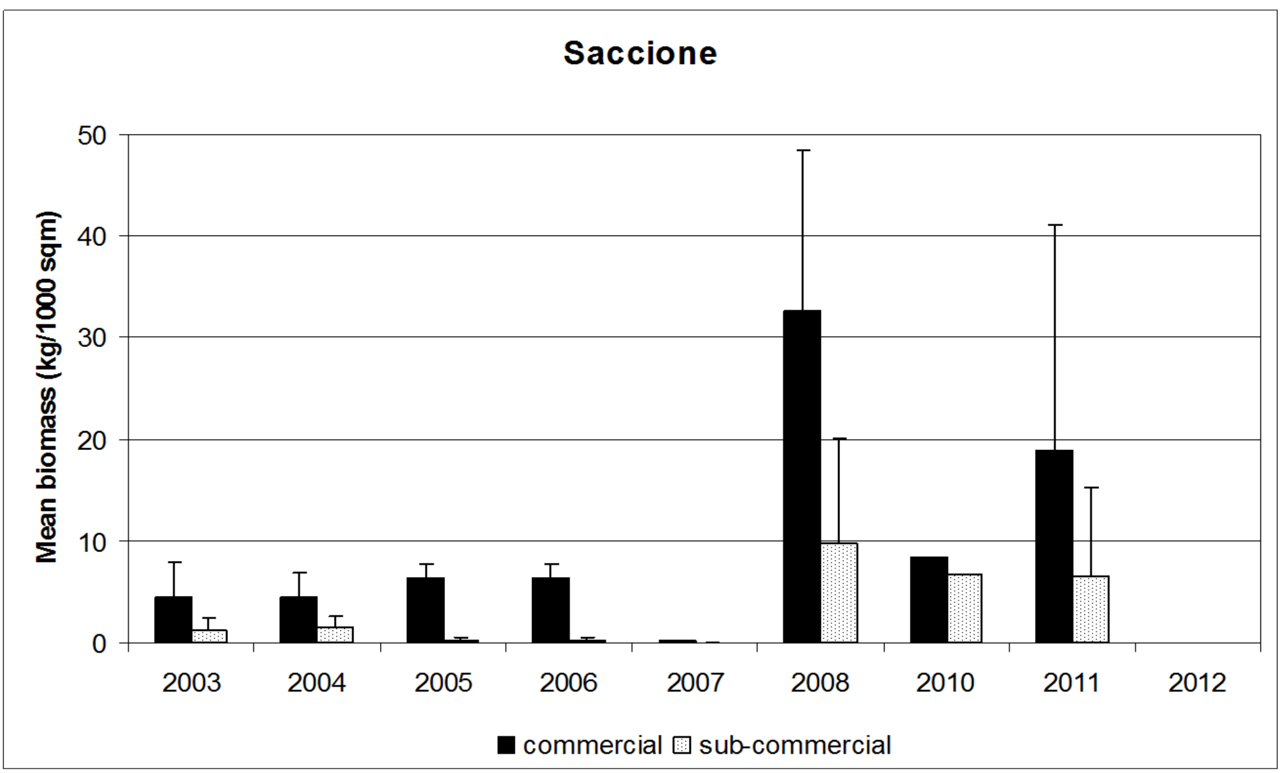

Figure 4 : Clam biomass annual variations in Saccione area during 2003-2012.

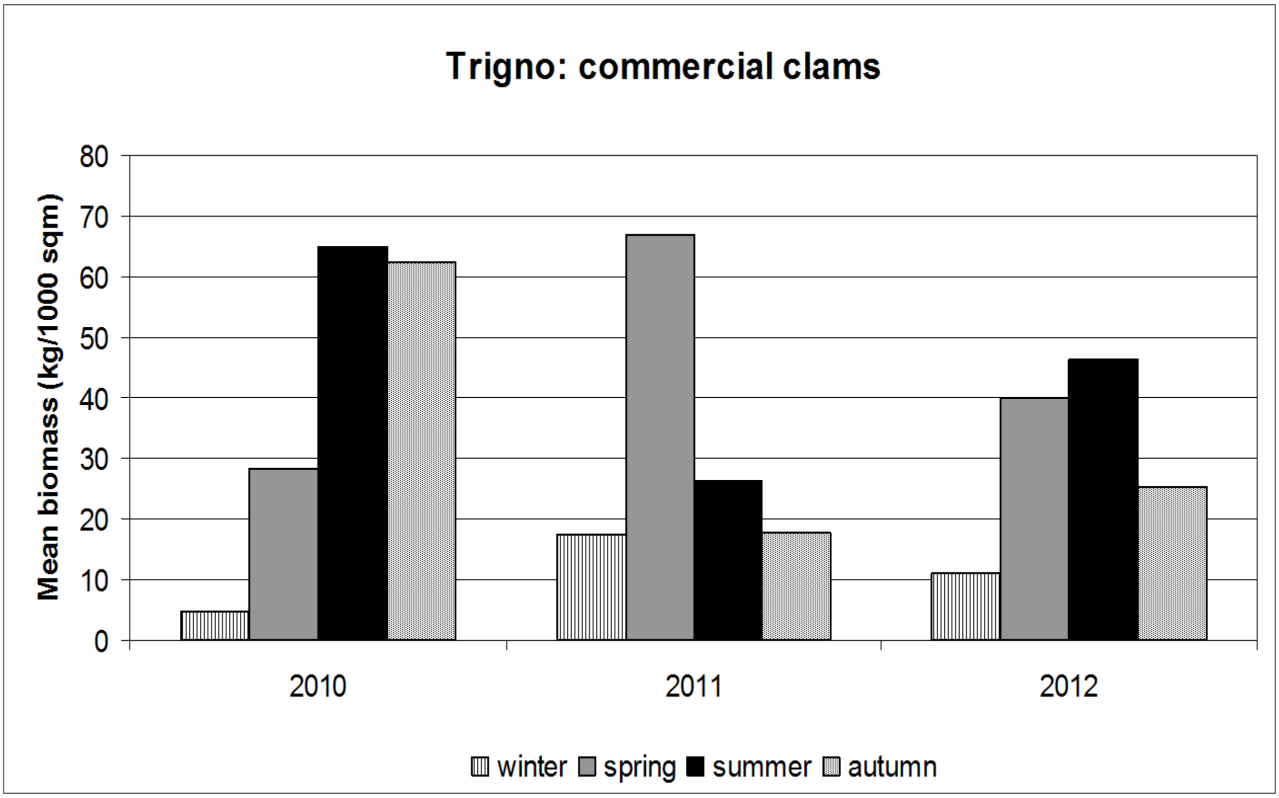

Figure 5 : Seasonal variations of commercial clams biomass in Trigno area during 2010-2012.

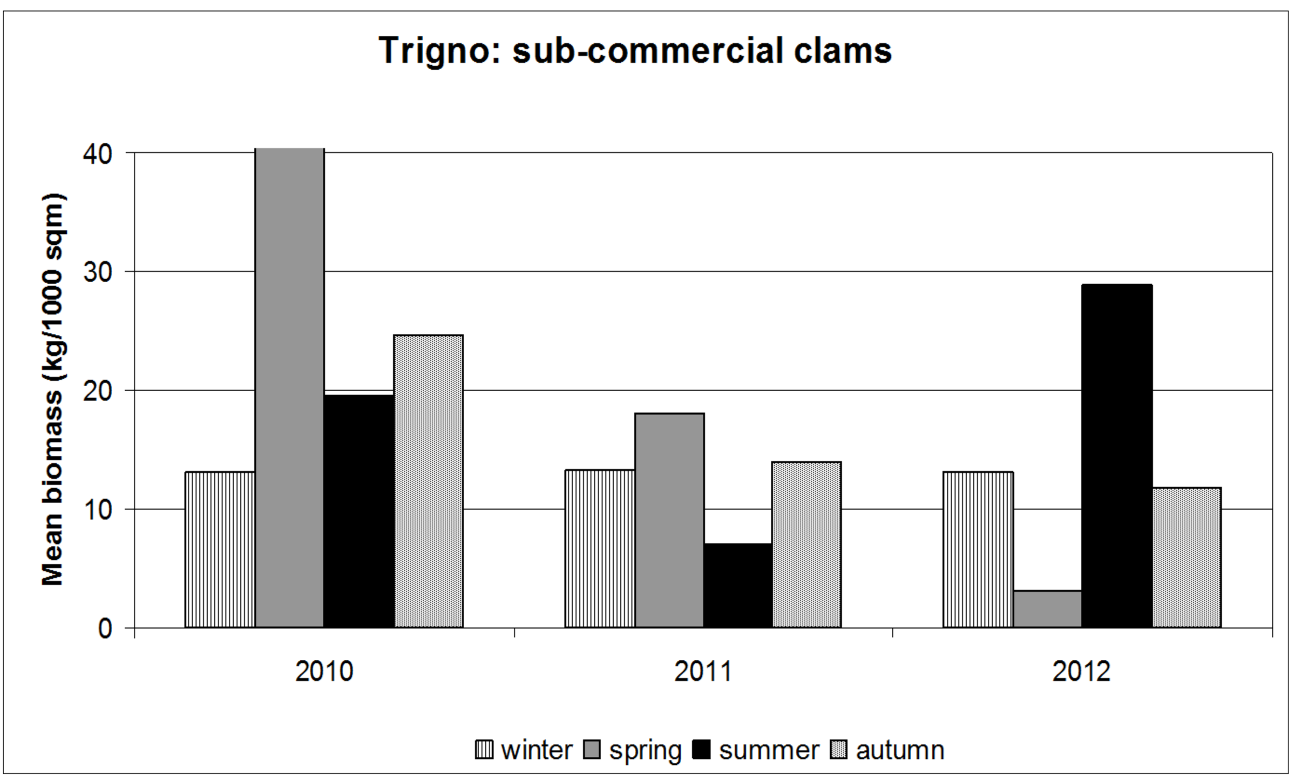

Figure 6 : Seasonal variations of not-commercial clams biomass in Trigno area during 2010-2012.

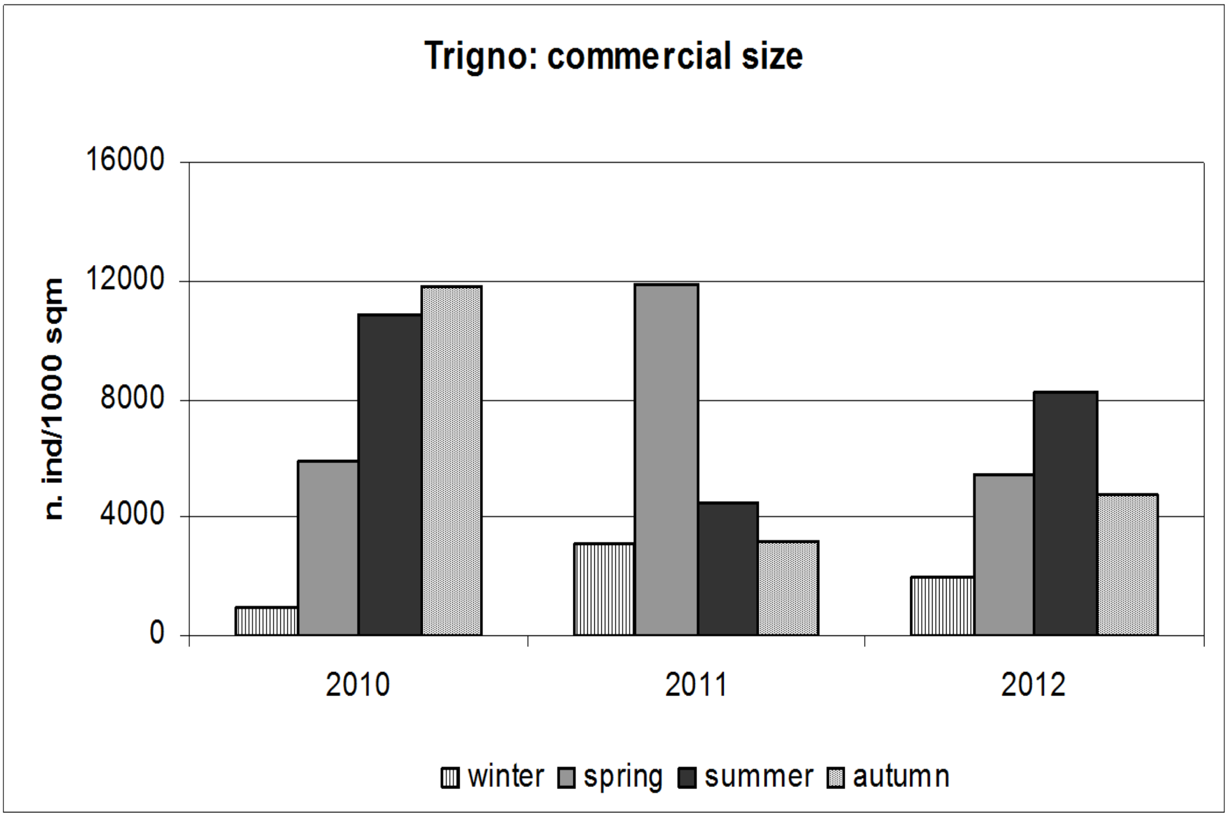

Figure 7 : Seasonal variations of commercial clams density in Trigno area during 2010-2012.

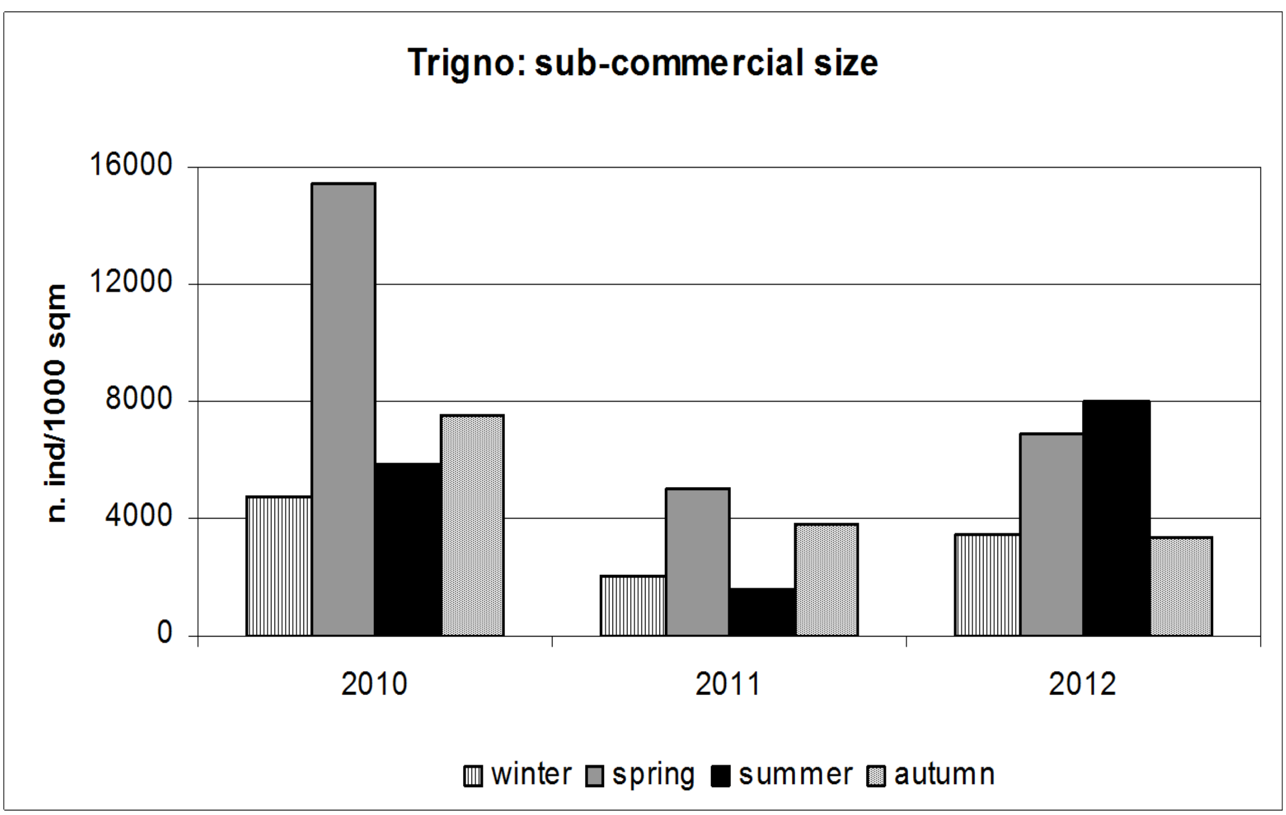

Figure 8 : Seasonal variations of not-commercial clams density in Trigno area during 2010-2012.

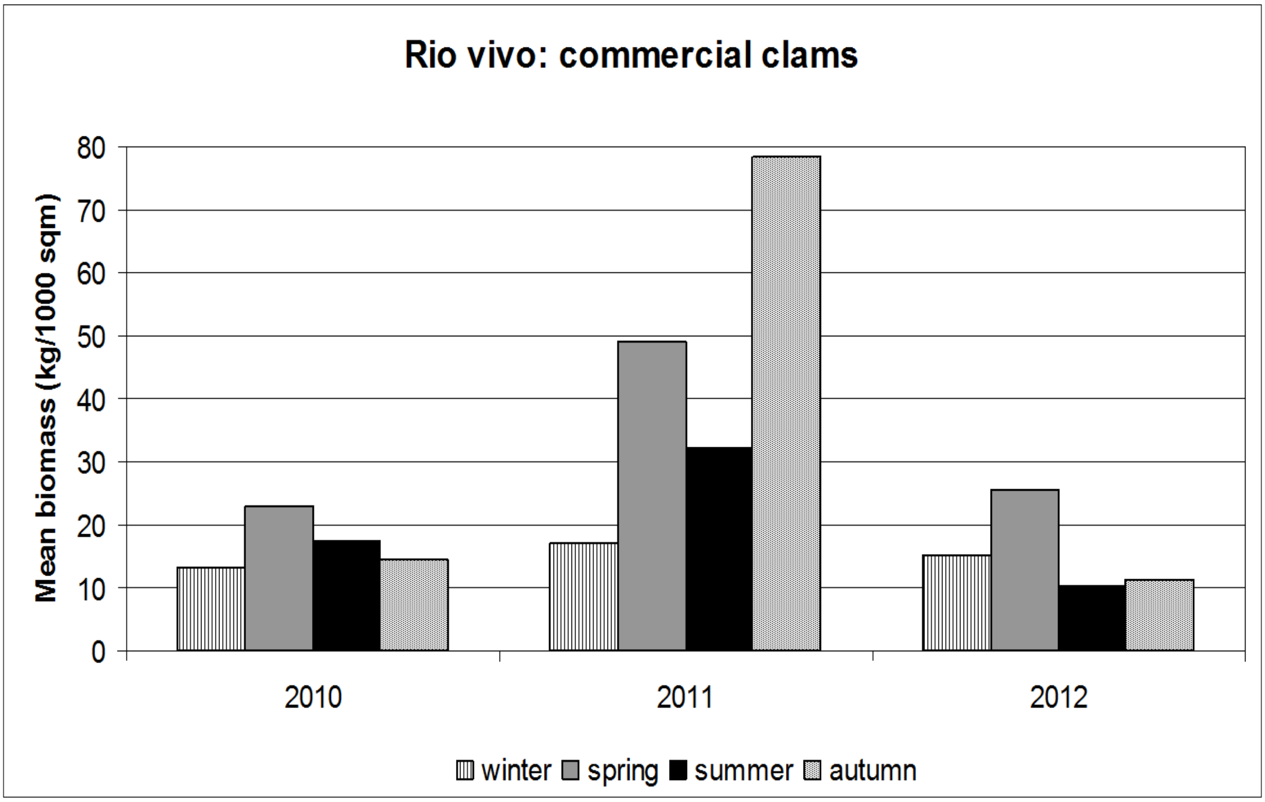

Figure 9 : Seasonal variations of commercial clams biomass in Rio vivo area during 2010-2012.

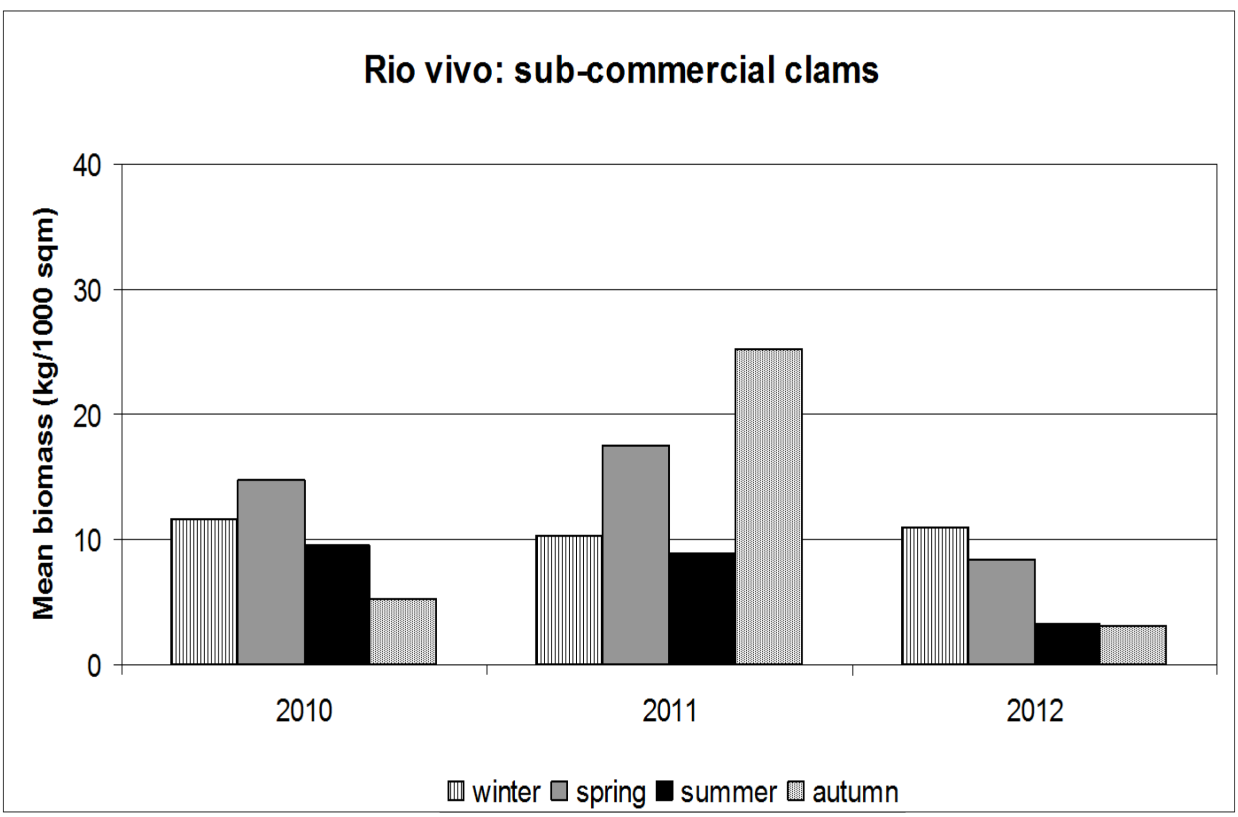

Figure 10 : Seasonal variations of not-commercial clams biomass in Rio vivo area during 2010-2012.

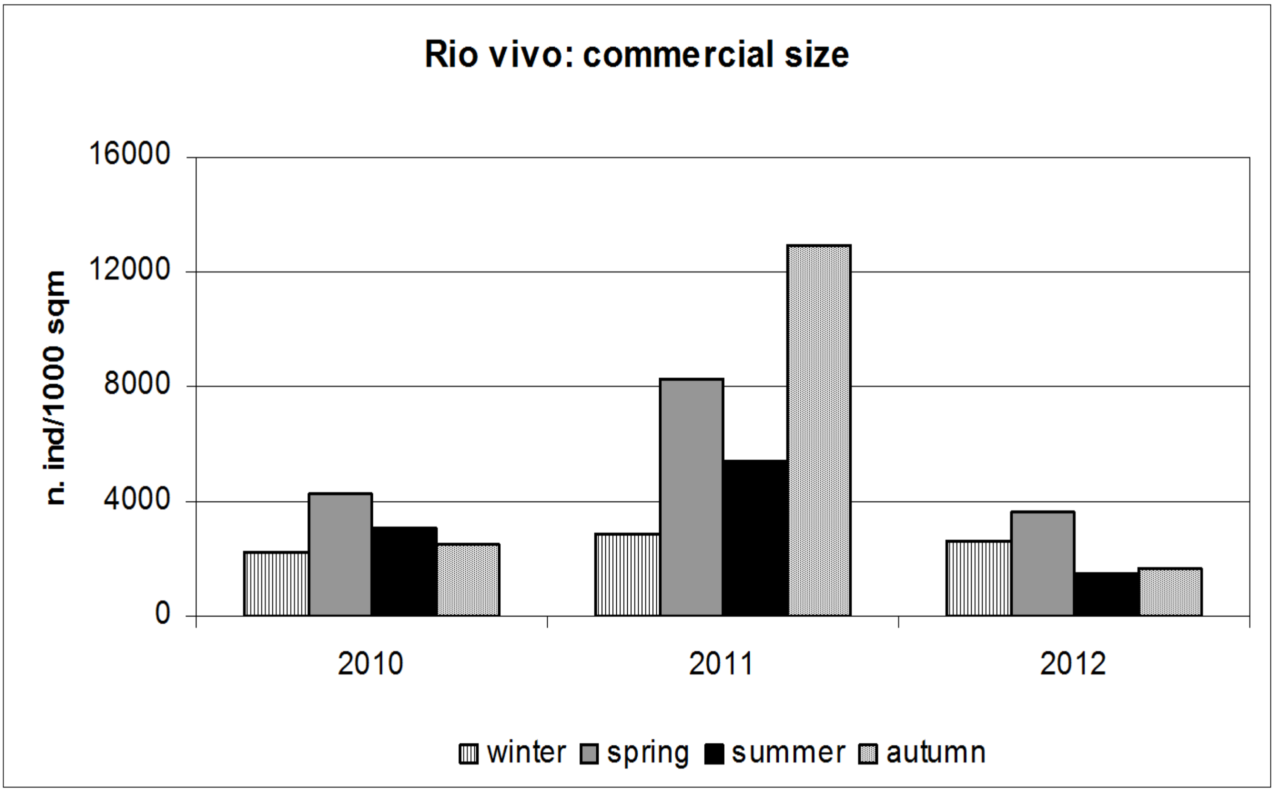

Figure 11 : Seasonal variations of commercial clams density in Rio vivo area during 2010-2012.

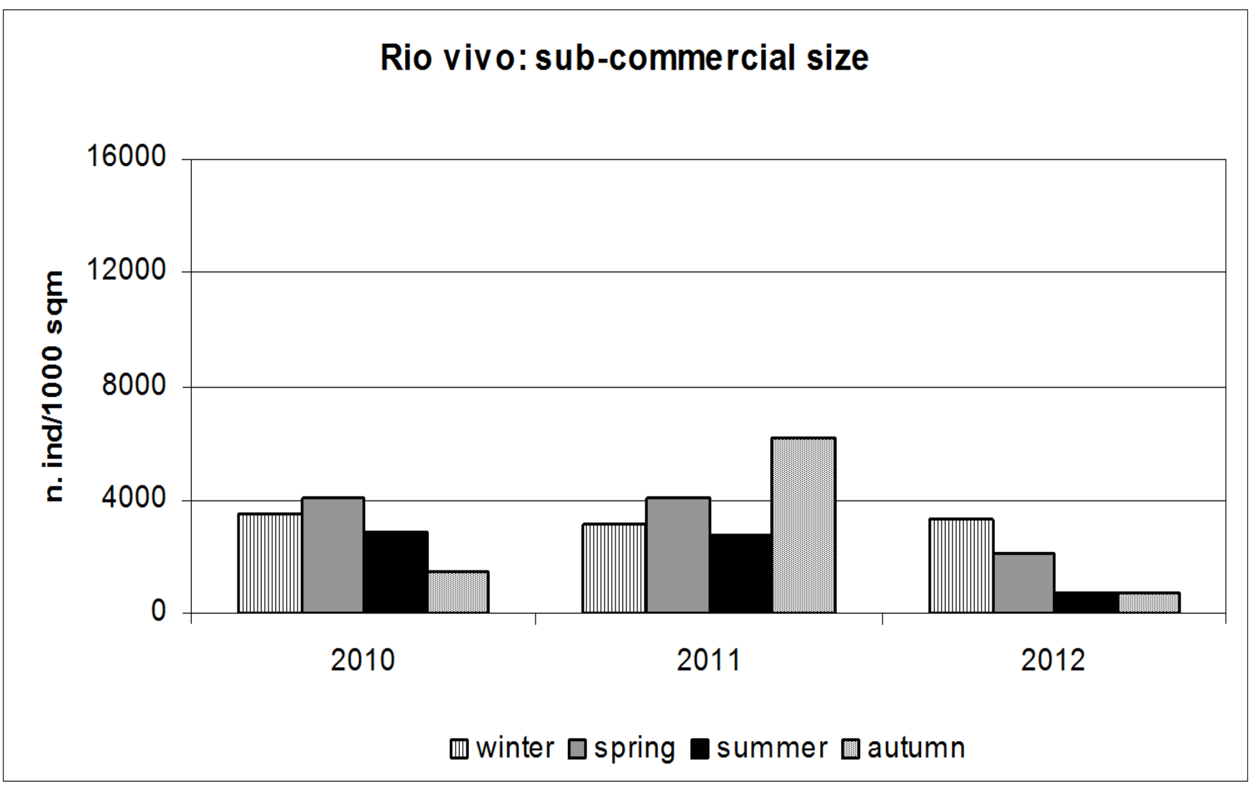

Figure 12 : Seasonal variations of not-commercial clams density in Rio vivo area during 2010-2012..

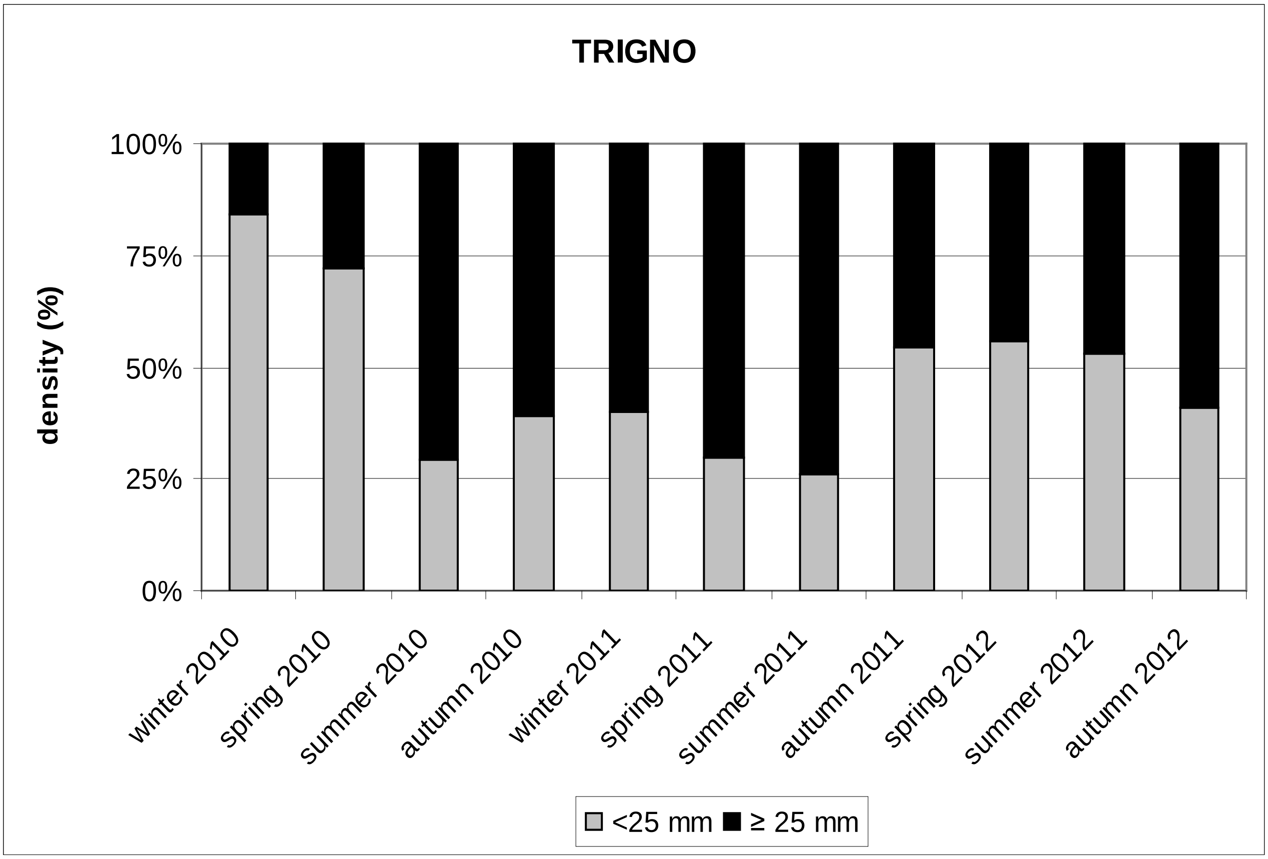

Figure 13 : Seasonal variations of commercial clams abundance percentage in Trigno area during 2010-2012.

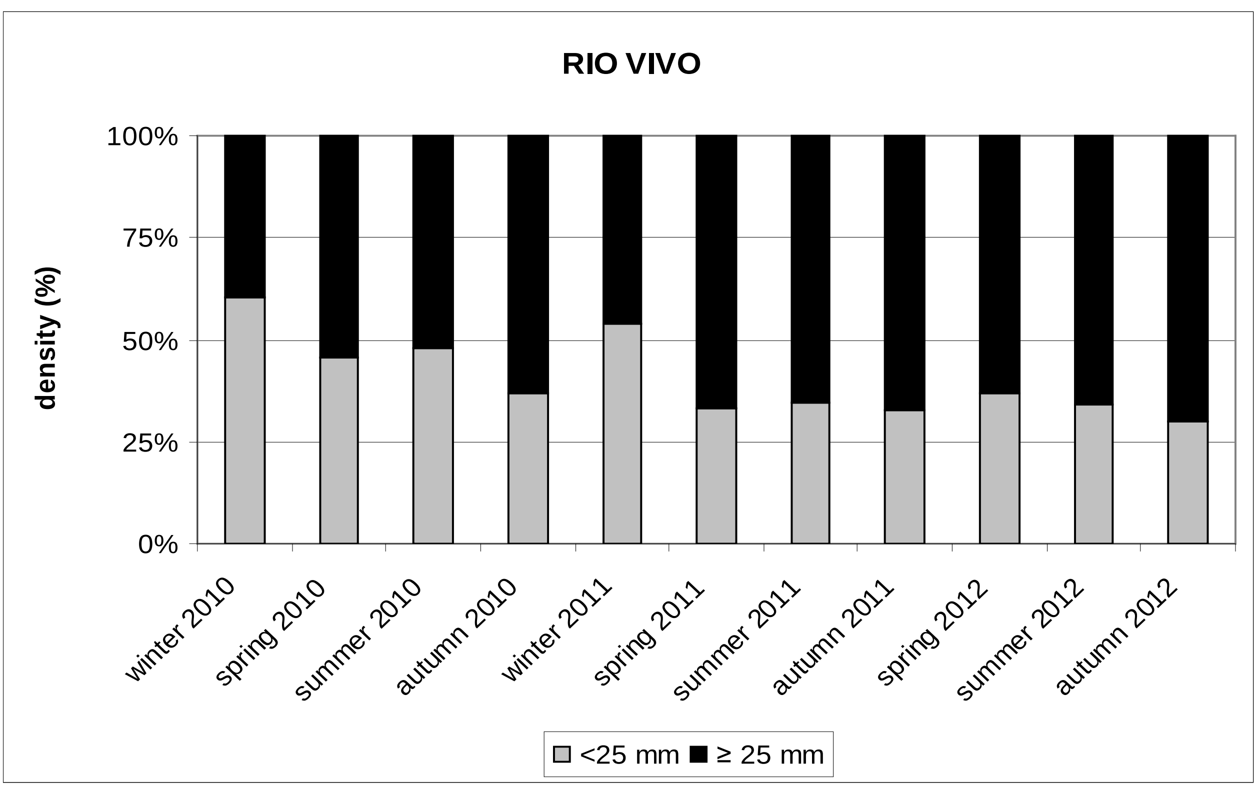

Figure 14 : Seasonal variations of commercial clams abundance percentage in Rio vivo area during 2010-2012.

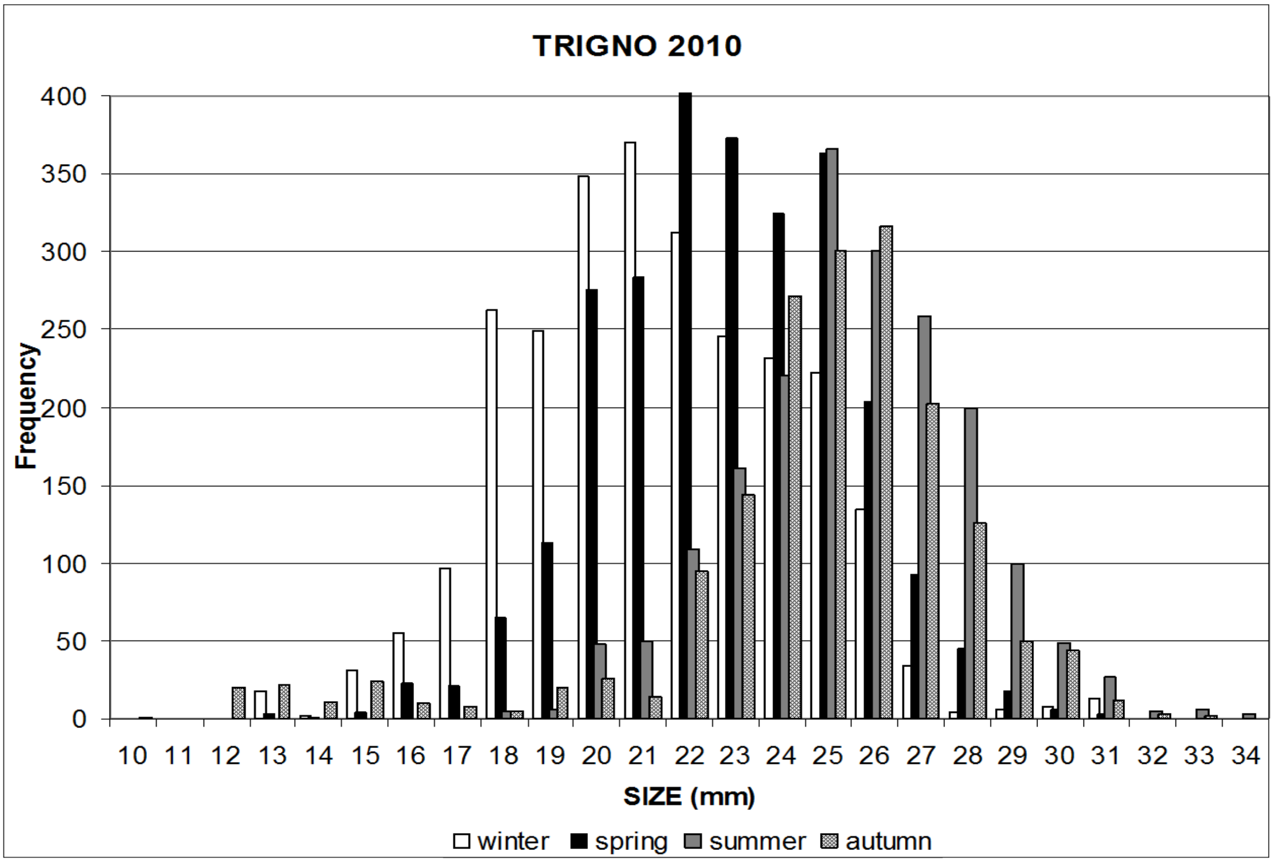

Figure 15 : Size-distribution of *Chamelea gall*ina population in Trigno area during 2010.

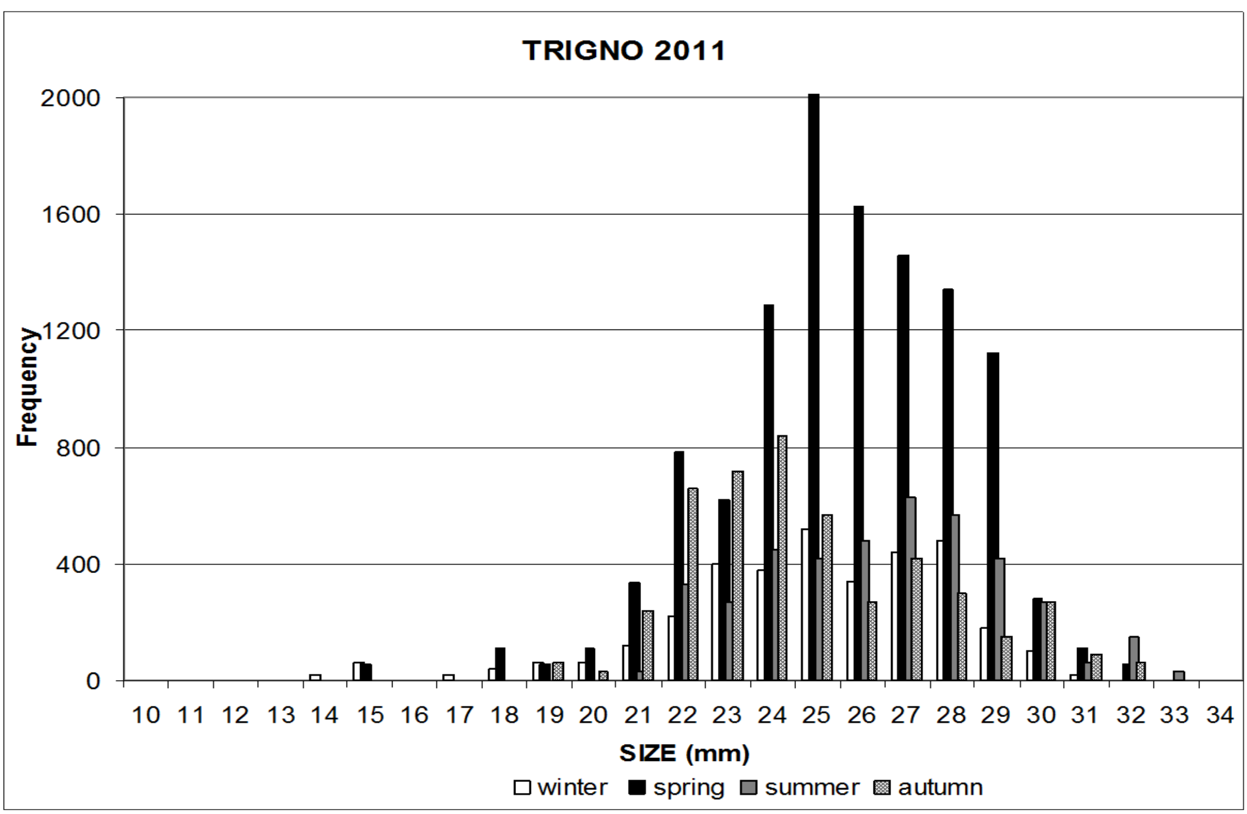

Figure 16 : Size-distribution of *Chamelea gallina* population in Rio vivo area during 2010.

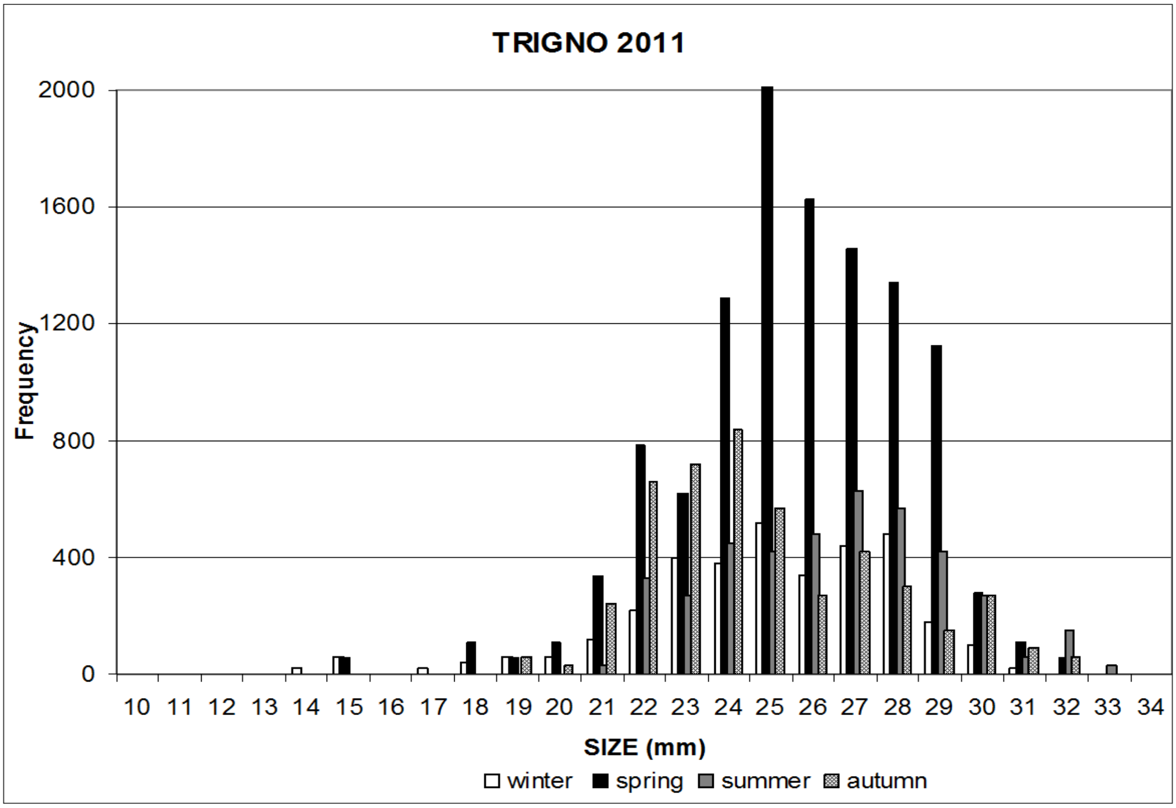

Figure 17 : Size-distribution of *Chamelea gallina* population in Trigno area during 2011.

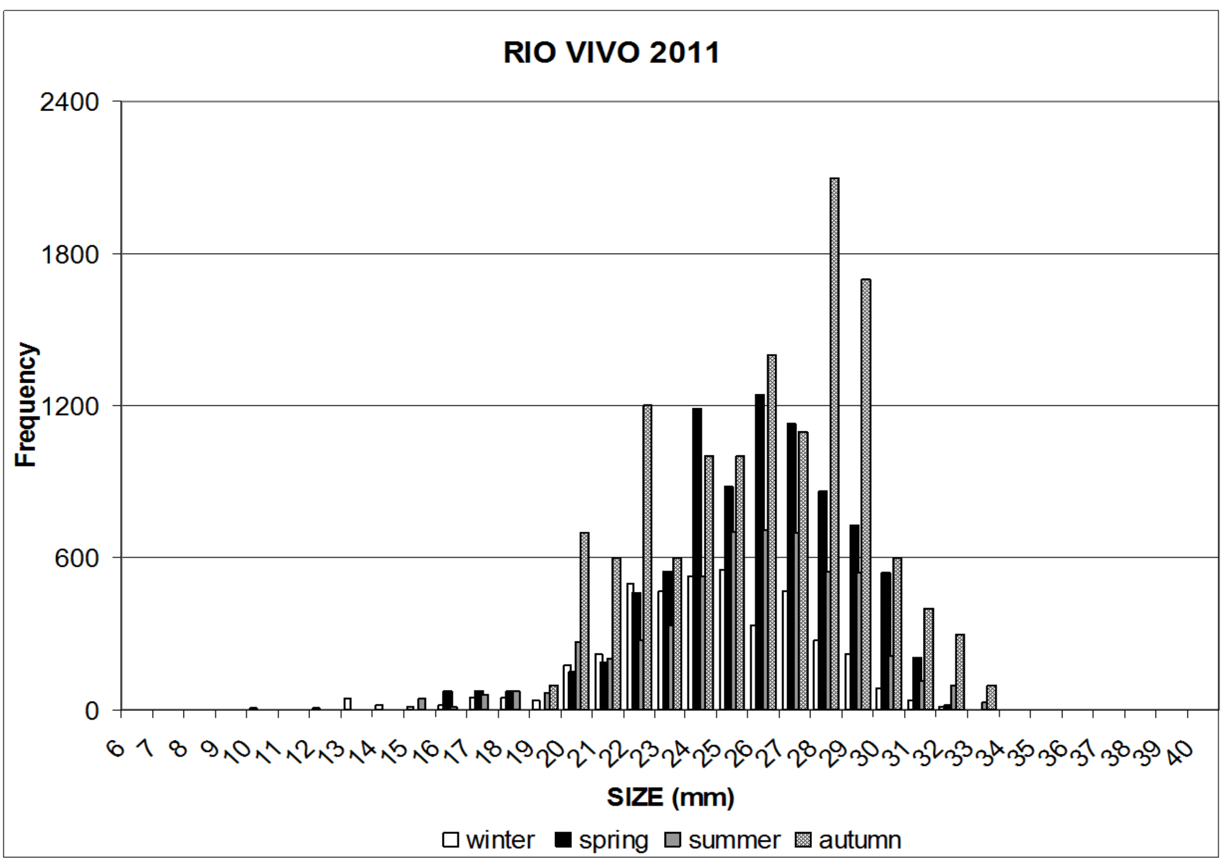

Figure 18 : Size-distribution of *Chamelea gallina* population in Rio vivo area during 2011.

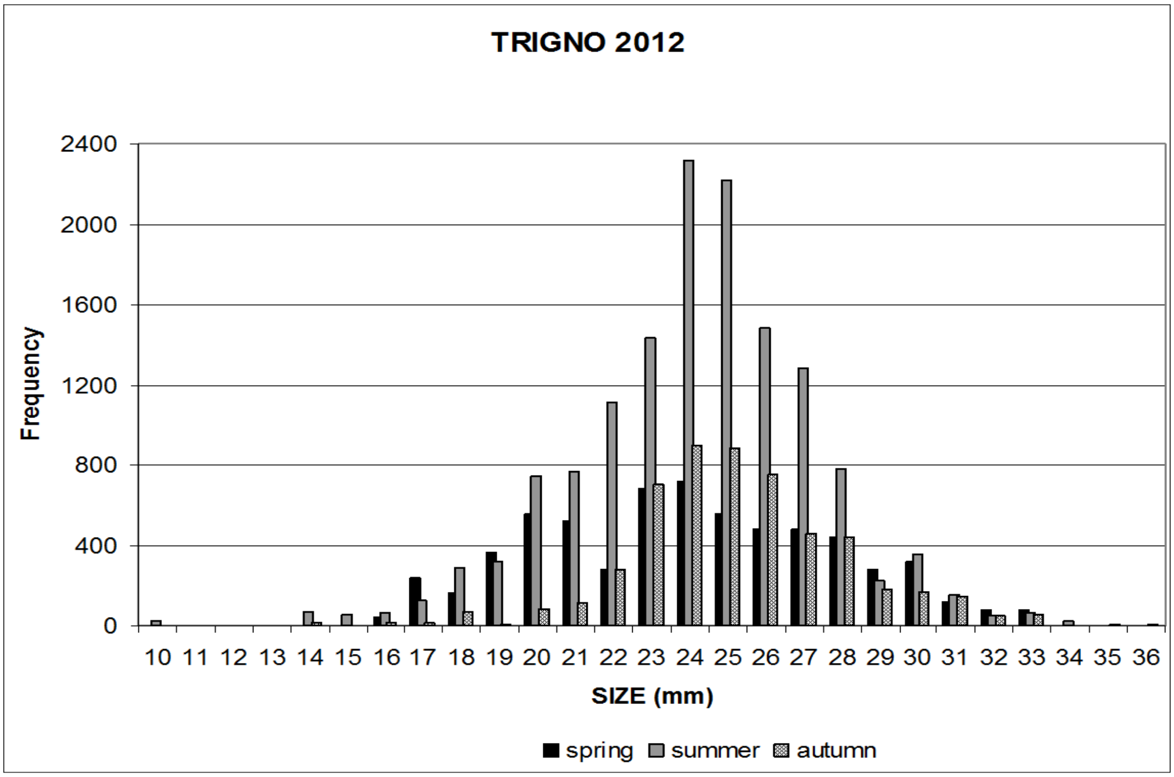

Figure 19 : Size-distribution of *Chamelea gallina* population in Trigno area during 2012.

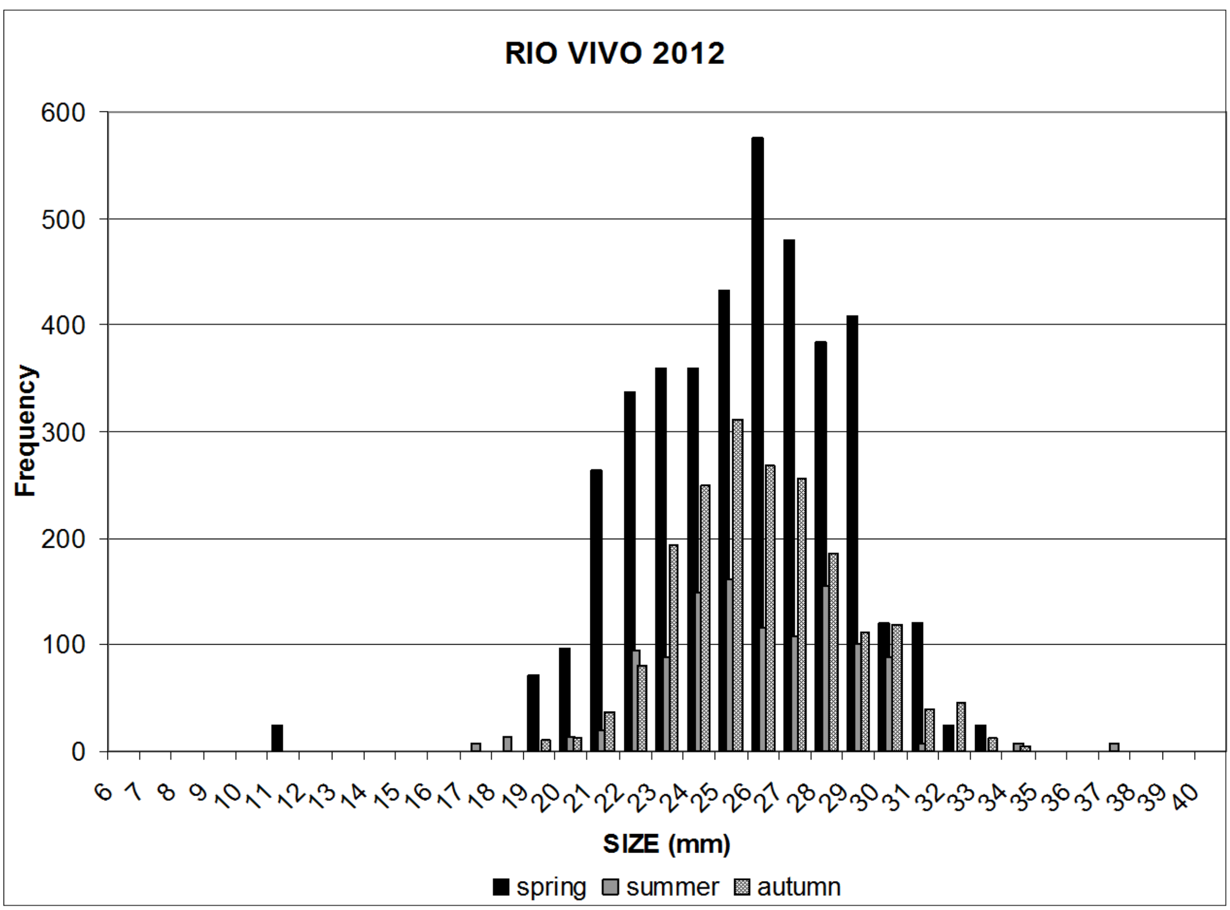

Figure 20 : Size-distribution of *Chamelea gallina* population in Rio vivo area during 2012.

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The Effect of Different Weed Control Methods on Weed Infestation, Growth and Yield of Soybeans (Glycine Max (L) Merril) in the Southern Guinea Savanna of Nigeria

By E.O. Imoloame
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Abstract- A field experiment was conducted during the 2012 and 2013 rainy season at the Kwara State University Teaching and Research Farm located in Malete. The aim was to determine the effect of different weed control methods on Weed infestation, growth and yield of soybeans (variety TGX 1448 – 2E). The experiment consisted of 8 treatments, namely, the application of metolachor at 1.5, 2.0 nd 2.5 kg a.i./ ha, pendimethalin at 1.5, 2.0 and 2.5 kg a.i./ha, a tank mixture of metolachlor + diuron at 1.5 + 0.5, 2.0 + 1.0 and 2.5 + 1.5 kg a.i./ha, pendimethalin + diuron at 1.5 + 0.5, 2.0 + 1.0 and 2.5 + 1.5 kg a.i./ha, metolachor at 2.0 kg a.i. /ha plus I supplementary hoe weeding (SHW) at 6 WAS, pendimethalin at 2.0 kg a.i. /ha plus supplimentary hoe weeding (SHW) at 6WAS, metolachlor + diuron at 1.0 +0.5 kg a.i. /ha plus ISHW, pendimethalin + diuron at 1.5 +0.5 plus ISHW at 6WAS, weeding at 3 and 6 WAS and a weedy check. Results show that all the herbicide treatments significantly reduced weed infestation compared with the weedy check. However, metolachlor + diuron integrated with ISHW was more effective than the application of only herbicides in the control of weeds throughout the crop life. This weed control method also resulted in significantly better growth and higher yield. Therefore for better growth and higher yields, metolachlor + diuron integrated with ISHW at 6 WAS is recommend to formers in the Southern Guinea Savanna of Nigeria.

Keywords: methods of weed control, soybean, southern Guinea savanna, nigeria.

GJSFR-D Classification : FOR Code: 820405, 070308

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I. Introduction

Soybeans (*Glycine max* (L.) Merrill) account for more than 50% of the world oil seed output (Joshi, 2001). In tropical Africa, important countries known for soybean production are Zambia, Nigeria, Zimbabwe, Zaria, Rwanda, Uganda and Ethiopia. The average yield of soybean in Nigeria is 1,000kg ha^{-1}, while the world average yield is about 1,800 kg ha^{-1}. However, with proper management, is possible to obtain 2,500 kg ha^{-1} (Onwueme and Sinha, 1991).

Soybean is an important grain legume and source of vegetable protein (Anon, 1994). It is popular as golden been and has become the miracle crop of the 21st century. It serves the dual purpose of being grown both as an oil crop and pulse crop as well (Thakare *et al*. 2006). The crop has an average protein content of 40% and is more protein – rich than any of the common vegetable or animal food sources found in Nigeria (Dugje *et al*., 2009). In addition to its use as a source of protein and fodder, soybean can improve soil fertility by contributing to soil nitrogen through nitrogen fixation (Kureh *et al*., 2005). It can be used for soy-milk and vegetable oil, as soybean seed contains about 20% oil on a dry matter basis and this is 85% unsaturated and cholesterol – free (Dugje *et. al*; 2009).

Poor soybean yield in farmers' plots is attributable to weed-crop competition and low soil fertility (Sodangi *et al*., 2011). Jannink *et al*. (2000) reported that root and shoot interferences are the main factors that cause soybean grain yield reduction. Sodangi *et al*. (2006) reported a soybean grain yield loss of up to 99% due to weed infestation in the Sudan Savanna zone of Nigeria. This is because in the early growth stages, soybean is a poor competitor with fast growing weeds and if such weeds are not controlled, they may out grow the crop (Sodangi *et al*., 2007). Also, Daugovish *et a*l. (2003) reported that up to 80% yield loss of soybean may occur as a result of weed competition in many parts of the world.

Traditional manual weeding is the most popular method of weed control in Nigeria. This is, however, time consuming, labour – intensive, strenuous and generally expensive (Joshua and Gworgwor, 2000; Adigun and Lagoke, 2003). It is estimated that about 40 – 60% of production cost is spent on manual weeding (Remission, 1979). In addition to high cost, labour availability is uncertain, thus making timeliness of weeding difficult to attain, leading to greater yield loss (Adigun and Lagoke, 2003).

Herbicide use is one of the recent developments in crop production, more adapted to large scale production and labour saving (Anon, 1994). Other factors that have made chemical weed control more popular than manual weeding include reduction of drudgery in chemical weed Control, it protects crops from the adverse effects of early weed competition which can avert economic losses in soybean that needs early weed control in the first four weeks as this is the critical period of weed completion in soybean. It is a

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faster weeds control method than cultural weed control (Akobundu, 1987). Furthermore, the use of herbicides is more profitable than hoe-weeding in the production of most crops in Nigeria (Shrock and Monaco, 1980; Okereke, 1983; Sinha and Lagoke, 1984; Ogungbile and Lagoke, 1986; Adigun et al., 1993 and Imoloame et al., 2010). Their judicious use has been reported to reduce the cost of weed control, increased crop yields by reducing weed competition and consequently increased profitbality (Ogungbile and Sinha, 1982). A survey carried out by Ikuenobe (2005) and Imoloame (2013), showed that majority of farmers using herbicides indicated savings in labour and cost of production, better weed control and higher crop yields.

Considering the determination of Kwara State government to modernize agriculture and make farming more attractive through the reduction of drudgery, there is need to evaluate different methods of weed control in order to determine the one that will be most effective in weed control and result in higher soybean grain yield.

II. Materials and Methods

A field experiment was conducted during the 2012 and 2013 rainy season at the Teaching and Research Farm of Kwara State University, Malete, (lat. 08^0, 71'H; log.$04^0$44'E) at 365 above sea level. The objective was to determine the effect of some weed control methods on weed infestation, growth and yield of soybeans. The experiment consisted of 18 treatments, namely, the application of metolachlor at 1.5, 2.0 and 2.5 kg a.i./ha, pendimethalin at 1.5, 2.0 and 2.5 kg a.i./ha, a tank mixture of metolachlor + diuron at 1.5+0.5, 2.0+1.0 and 2.5+ 1.5 kg a.i./ha, pendimethalin + diuron at 1.5 + 0.5, 2.0 + 1.0 and 2.5 + 1.5 kg a.i./ha metolachlor at 2.0 kg a.i./ha plus I SHW at 6WAS, pendimethalin at 2.0 kg a.i./ha plus 1SHW at 6 WAS, metolachlor + diuron at 1.0 +0.5 plus ISHW, pendimethalin + diuron at 1.5 +0.5 plus I SHW at 6 WAS, weeding at 3 and 6 WAS and a weedy check. These treatments were laid out in a Randomized Complete Block Design (RCBD) and replicated three times. The variety of soybean that was used was TGX 1448 – 2E which was sown on 2nd of July 2012 and 28 June, 2013 and harvested on the 15th and 7th of November respectively. The crop was spaced at 40cm x 10cm to produce a plant population of 500,000. Herbicides were applied a day after planting with a CP3 knapsack sprayer which was calibrated to deliver 250 L /ha spray volume. Fertilizer was applied at the rate of 20 kg N, 20 kg P and 10 kg k_2O. These were provided with a compound fertilizer 15:15:15. The gross plot was $3x3m^2$ while the net plot was $1.2_n x\ 3m^2$. The outer rows were discarded while only the 5 inner rows were harvested and weighed. The parameters measured were plant height, weed dry matter, weed cover scores, crop vigour, phytotoxicity, 100 – seed weight and soybean grain yield. Data collected were subjected to analysis of variance and means were separated using Duncan's Multiple Range Test at 5% level of probability.

III. Result and Discussion

Weeds observed on the experimental farm included, *Celosia leptostachya Benth, Hyptis lanceolata Poir, Mariscus alternifolius* vahL (=M. unbellatus Vahl), Hyptis suaveolens Poit and *Leucas martinicensis occure* at high levels of infestation, *Daniellia oliveri commelina benghalensis, Cyperus esculentus, Cyperus roturdus, Brachiaria Lata*, Chloris pilosa, *Dactyloctenium aegytium Digitaria horizontalis, Pennisetum Pedicellatum and Rottboelia conchinchinensis*. Table 1 shows the effect of different methods of weed control on weed dry matter at 6 WAS and harvest. It shows that different methods of weed control significantly affected weed dry matter in both years and their means. Weeding twice at 3 and 6 WAS significantly reduced weed dry matter at 6 WAS compared with the other treatments in both years and the combined except. metolachlor at 1.5kga.i. /ha, pendimethalin at 2.0 and 2.5 kg a.i./ ha, a tank mixture of metolachlor + diuron at 2.0+1.0 and 2.5+1.5 kg a.i./ha, a tank mixture of pendimethalin + diuron at 2.5 + 1.5 kg a.i./ha, metolachlor at 2.0 Kg a.i. plus I SHW, metolachlor + duiron and pendimethalin + diuron at 1.5 +0.5 kg a.i./ha integrated with I SHW. Weedy check supported significantly higher weed infestation. However at harvest, metolachlor + diuron and pendimethalin + diuron at 1.5 + 0.5 kg a.i./ha integrated with 1 SHW at 6 WAS , two hoe weedings metolachlor and pendimethalin at 2.0 kg a.i./ha integrated with I SHW sustained their effectiveness in the control of weeds till harvest. Integrating metholachlor + diuron at 1.5 + 0.5 with I SHW at 6 WAS and pendimethalin at 2.0 kg a.i./ha plus 1SHW supported significantly lower weed dry mater in both years and the combined than the other weed control treatment except hoe weeding at 3 and 6 WAS pendimethalin at 2.0 kg a.i./ha in 2013 and metolachlor at 2.0 kg a.i./ha plus I SHW in 2012. This clearly underscores the importance of integrated weed management in enhancing weed control compared with the use of single weed control method. (Table 1). Also using only herbicides at the above doses were only effective in weed control up to 6 WAS. However they become ineffective with time.

The effect of different methods of weed control on weed cover scores at 6 WAS and at harvest is presented in table 2. Different methods of weed control significantly affected weed cover scores. At 6 WAS in the mean, metolachlor at 2.0 kg a.i.lha supported significantly lower weed cover score than the other treatments, except pendimethalin at 2.0 kg a.i./ha plus ISHW, two hoe weedings, pendimethalin at 1.5 +0.5 kg a.i./ha plus I SHW, metolachlor + diuron at 1.5 + 0.5 and 2.5 + 1.5 kg a.i./ha and pendimethalin + diuron at

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2.5 + 1.5 kg a.i./ha. However at harvest herbicides alone poorly controlled weeds, while two hoe weeding resulted in comparable significantly lower weed cover with metolachlor + duiron and pendimethaline + duiron at 1.5 + 0.5 kg a.i./ha integrated with I SHW, and metolachlor or pendimethalin integrated with I SHW. Other herbicide treatments along with weedy check resulted in significantly higher weed cover scores in both years and their means. This result corroborates the findings of Peer (2013) that herbicide proved effective at higher rates when applied alone, however when combined with one hoe weeding, they were more effective, and that the initial achievement of limiting weed growth by the herbicides is maintained as hand weeding eliminates the fresh flush of weeds that may regenerate due to loss of persistence of herbicides applied alone. (Table 2) Also the integrated weed control method ensured early canopy closure which further suppressed late emerging weeds. This is in line with the report of (Gebharat and minor, 1983, murphy and Gossett, 1981; MIckelson and Runnur 1997, Yelverlon and coble, 1991) that if weeds are controlled within the first five weeks after sowing, the canopy of narrow-sown soybean can suppress late emerging weeds. Table 3.presents the effect of different methods of weed control on phytotoxicity of soybean at 2, 4 and 8 WAS. In 2013 at 2 WAS, it was only pendimethalin at 2.0 kg a.i./ha, a tank mixture of pendimethalin + duiron at higher dose and metolachlor at 2.0 kg a.i./ha plus I SHW that were significantly phytotoxic to soybean, however at time progressed to 4 WAS and 8 WAS this effect was neutralized. In the mean at 2 WAS, all the herbicide rates did not have any phytotoxic effect on soybean indicating that all the herbicides used were safe to be used for weed control in soybean (Table 3).

Table 4 presents the effect of different methods of weed control on soybean plant height at 6 WAS and at harvest. It shows that at 6 WAS, while different methods of weed control had no significant effect on soybean plant height in 2012, they affected soyabean plant height significantly in 2013 and the mean.

In both 2013 and the mean, metolachlor + diuron at 1.5 + 0.5 kg a.i./ha plus I SHW supported comparable significantly taller soybeans plants with other herbicides treatments and two hoe-weedings except pendimethalin at 2.0 and 2.5 in 2013 and the mean respectively, pendimethalin + diuron at 2.0 + 1.0 and pendimethalin + diuron at 1.5 + 0.5 kg a.i./ha plus supplementary hoe weeding in the mean and weedy check which supported significantly shorter soybean plants. However at harvest, all the weed control treatment produced significantly taller plants except pendimethalin at 2.0 kg a.i./ha, pendimethaline + diuron at 2.5 + 1.5 kg a.i./ha in 2013 and metolachlor and pendimethalin at 2.0 kg a.i./ha plus I SHW in the mean. Weedy check gave significantly shortest soybean plants. Plots treated with metolachlor + diuron at 1.5 +0.5 kg a.i./ha and other weed control treatments supported significantly taller soybean plants than the weedy check because of their ability to effectively control weeds which allowed the soyabean plants to utilize more nutrient, moisture and sunlight for better performance. The shortest soyabean plants were produced by the weedy check as a result of the greater intensity of weed competition with crop for growth resources which led to poor performance of the crop. The shorter soybean plants observed under pendimentalin at 2.0 kg a.i./ha in 2013 and could be due to the slight phytotoxicity of the herbicides at the early stage of crop growth which disappeared as the plant grew older.

Table 5, shows the effect of different methods of weed control on soybean crop vigour. It shows that different methods of weed control affect soybean crop vigour at 6WAS and at harvest in 2013 and the mean. A tank mixture of metolachlor + dluron at 1.5 + 0.5 kg a.i./ha plus I SHW produced significantly vigorous crops which were comparable with other weed control treatments except pendimethalin at 2.0 kg a.i./ha in 2013 and pendimethalin + duiron at 2.5 + 1.5 kg a.i./ha and weedy check in 2013 and the mean which gave significantly weaker crops. At harvest, similar observation was obtained with a tank mixture of matolachlor + diuron at 1.5 +0.5 kg a.i./ha plus ISHW producing significantly most vigorous crops in 2013 and the mean which was comparable to melolachlor at 2.0 kg a.i./ha, metolachlor + diuron at 1.5+ 0.5 and 2.0 + 1.0 kg a.i./ha, pendimethalin + diuron at 1.5+0.5 and 2.0+1.0 kg a.i.Iha, and two hoe weedings. The other weed control treatments and the weedy check resulted in significantly weaker plants. Metolachlor + diuron at 1.5 + 0.5 kg a.i./ha plus I SHW consistently produced significantly most vigorous crops as a result of its greater ability of this weed control method to control weeds more effectively than other control methods. This made more growth resources to be available for use by the crops under this treatment resulting in a better performance.

The weedy check consistently supported significantly weaker crops at 6 WAS and harvest than the other weed control methods due to the greater weed competition with soybean crop which significantly reduced the amount of assimilates, nutrients, moisture and solar radiation utilized by the crop leading to poor performance.

Table 6, presents the effect to different methods of weed control on 100-seed weight and soybean grain yield. The effect of different methods of weed control on 100-seed weight was not significant in 2012 while it was significant in 2013 and their mean. In 2013 and the combined, tank mixture of metolachlor + diuron at 1.5 + 0.5 plus I SHW gave significantly heaviest soybean seeds which were comparable to metolachlor at 2.5 kg a.i./ha, pendimethalin at 1.5 kg a.i./ha pendimethalin + diuron at 1.5 +0.5 and 2.0 + 1.0 kg a.i./ha, pendimethalin at 2.0 kg a.i./ha plus I SHW, pendimethalin + diuron at 0.5 +1.0 kg a.i./ha plus I SHW and two hoe weedings but significantly heavier than the rest of the weed control methods and weedy check. This further reveals the effectiveness of the above weed control methods to significantly reduce weed cover thereby minimizing weed competition with the soyabean crop leading to uptake of more nutrients, moisture and sunlight and assimilate for the production of heavier seeds.

Similarly, different methods of weed control affect soyabean grain yield significantly only in both years and their mean. In 2012 all the weed control methods resulted in comparable significant higher grain yield than the weedy check. However in 2013, a tank mixture of metolachlor + diuron at 1.5 +0.5 kg a.i./ha integrated with 1 SHW produced significant higher grain yield than all the other weed control methods, except two hoe weedings at 3 and 6 WAS. Similar trend was observed in the mean with a tank mixture of metolachlor + diuron at 1.5 + 0.5 kg a.i./ha producing significant higher yield which was comparable with other weed control methods except metolachlor at 1.5 and 2.0 kg a.i./ha, pendimethalin at 1.5 kg a.i./ha, metolachlor + duiron at 1.5 +0.5 kg a.i./ha and the weedy check which produced significantly lower soybean grain yields. Generally, 2012 recorded higher grain yields across treatments than 2013. In 2012, all the weed control methods produced significantly higher soybean grain yield than the weedy check because the weed control methods significantly reduced weed infestation compared to the weedy check which allowed crops to utilize more growth factors for better growth. However in the weedy check weed competition for growth resources with the soyabean crop was more intense, resulting in yield losses between 76.80% in 2012 and 89.3% in 2013. The higher percentage of losses and lower grain yields recorded in 2013 compared to 2012, could be due to the prolonged period of drought that was experienced in 2013 which limited the amount of moisture, nutrients and assimilate that were taken up by the crop. This situation was worsened by the greater weed cover that was observed in the plots probably due to the reduction of the potency of the herbicides as a result of the drought condition.

Metolachlor + diuron at 1.5 + 0.5 kg a.i. /ha and weeding at 3 and 6 WAS proved to be more effective than the other weed control methods as a result of their greater ability to continuously reduce weed infestation at the critical period of weed interference of soybean, thereby making more growth resources available to soybean for utilization. This led to significantly more vigorous crops, taller plants, heavier seed weight and higher grain yield. This result is similar to the findings of Peer et al. (2013) that hand weeding twice and both fluchoralin and pendimethalin integrated with hand weeding recorded far superior yields of soybean seed. Also, a number of researchers like Veeramani et al. (2001) held similar views and reported more pods with integrated use of herbicides with hand weeding. Uncontrolled weeds resulted in 89.3% and 76.8% soyabean losses in 2012 and 2013 respectively. This Iis similar to the findings of Sodangi et al. (2006) that soybean grain yield loss of up to 99% was due to weed infestation in the Sudan Savanna Zone of Nigeria.

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Table 1 : Influence of different methods of weed control on weed dry matter, 2012 and 2013.

Treatment	Rate kg a.i./ha	WEED DRY MATTER					
		6WAS			HARVEST		
		2012	2013	Mean	2012	2013	Mean
Metolachlor	1.5	246.7bc	144.0cd	195.3bc	1777.8ab	1022.0ab	1399.9ab
Metolachlor	2.0	428.0ab	146.3cd	287.1b	955.6ab	999.9ab	977.7ab
Metolachlor	2.5	460.9ab	168.9bc	314.9b	1911.1a	666.6bc	1288.8ab
Pendimethalin	1.5	435.6ab	128.5cd	282.0b	1627.0ab	633.2bc	1130.1ab
Pendimethalin	2.0	164.0bc	197.1ab	180.6bc	1555.6ab	822.2ab	1188.9ab
Pendimethalin	2.5	216.9bc	187.3ab	202.1bc	1288.9ab	1144.4ab	1216.7ab
Metolachlor + diuron	1.5+0.5	206.2bc	117.7cd	162.0bc	1422.6ab	833.3ab	1128.9ab
Metolachlor + diuron	2.0+1.0	276.0bc	136.0cd	206.0bc	1511.5ab	684.4bc	1098.0ab
Metolachlor + diuron	2.5+1.5	192.0bc	128.9cd	160.4bc	1018.1ab	955.6ab	986.8ab
Pendimethalin+diuron	1.5+0.5	393.3ab	155.7bc	274.5b	1533.3ab	777.8bc	1155.5ab
Pendimethalin+diuron	2.0+1.0	353.3ab	268.9ab	311.1b	1044.5ab	788.9bc	916.7ab
Pendimethalin+diuron	2.5+1.5	175.1bc	162.7bc	168.9bc	333.7ab	733.3bc	533.5ab
Metolachlor +I SHW	2.0	212.9bc	129.1cd	171.0bc	62.6cd	300.0de	181.3de
Pendimethalin+ I SHW	2.0	445.8ab	117.5cd	281.7b	14.0d	188.9ef	101.4ef
Metolachlor +diuron+I SHW	1.5+0.5	252.9bc	157.8bc	205.3bc	1.0d	155.5f	78.3f
Pendimethalin+diuron+ISHW	1.5+0.5	176.0bc	164.4bc	170.2bc	222.9bc	377.7cd	300.3bc
Weeding at 3 and 6 WAS	-	57.3c	54.9d	56.1c	333.7ab	155.9f	244.8cd
Weedy Check	-	622.2a	291.3a	456.8a	1377.8ab	1422.2a	1400.0a
SE(±)		26.63	9.9	2.01	150.50	59.61	12.3

I=Weeks after sowing 2=columns with the same letters are not significantly different at 5% level of probability according to Duncan's Multiple Range Test (DMRT) 3= Supplementary hoe weeding.

Table 2 : Influence of different methods of weed control methods on weed cover scores, 2012 and 2013.

Treatment	Rate kg a.i.lha	WEED COVER SCORES					
		6WAS[1]			HARVEST		
		2012	2013	Mean	2012	2013	Mean
Metolachlor	1.5	4.0bc[2]	7.0b	5.5b	6.7ab	9.7a	8.2ab
Metolachlor	2.0	3.7bc	4.5bc	4.1bc	6.0ab	9.0a	7.5bc
Metolachlor	2.5	4.3bc	3.2e	3.8bc	4.2cd	8.7a	6.4bc
Pendimethalin	1.5	3.3bc	3.7de	3.5cd	6.7ab	8.8a	7.6bc
Pendimethalin	2.0	1.8cd	6.2bc	4.0bc	5.3bc	8.3a	6.8bc
Pendimethalin	2.5	4.0bc	6.7bc	5.3bc	6.7ab	8.0a	7.3bc
Metolachlor + diuron	1.5+0.5	1.8cd	3.5de	2.7e	3.2de	7.7ab	5.4e
Metolachlor + diuron	2.0+1.0	2.3 bc	4.8bc	3.6cd	6.3ab	8.0a	7.2bc
Metolachlor +diuron	2.5+1.5	1.8cd	2.8e	2.3e	3.5de	7.7a	5.6de
Pendimethalin+ diuron	1.5+0.5	4.0bc	5.3bc	4.7bc	8.7ab	8.7a	8.7ab
Pendimethalin+ diuron	2.0+1.0	2.8bc	4.7bc	3.8bc	7.8ab	8.0a	7.9ab
Pendimethalin+ diuron	2.5+1.5	1.7cd	5.0bc	3.3de	3.7cd	8.0a	5.8cd
Metolachlor +I SHW	2.0	1.3d	3.8cd	2.6e	1.8ef	3.7c	2.8f
Pendimethalin+ I SHW[3]	2.0	2.8bc	2.8e	2.8de	1.5f	4.7b	3.1f
Metolachlor + diuron+I SHW	1.5+0.5	5.0b	3.1e	4.1bc	3.8cd	2.3c	3.1f
Pendimethalin+diuron+ISHW	1.5+0.5	2.0cd	4.5bc	3.3de	1.7f	3.0c	2.3f
Weeding at 3 and 6 WAS	-	1.8cd	5.0bc	3.4de	1.3f	3.5c	2.4f
Weedy Check	-	9.0a	9.8a	9.4a	10.0a	1.0a	10.0a
SE(±)		0.30	0.49	0.03	0.43	0.39	0.05

I=Weeks after sowing 2=columns with the same letters are not significantly different at 5% level of probability according to Duncan's Multiple Range Test (DMRT) 3= Supplementary hoe weeding.

Table 3 : Influence of different methods of weed control on phytotoxity of soybean

Treatment	Rate kg a.i./ha	PHYTOTOXICITY RATING								
		2WAS			4WAS			8WAS		
		2012	2013	Mean	2012	2013	Mean	2012	2013	Mean
Metolachlor	1.5	1.0a	1.0b	1.0b	1.0a	1.0a	1.0a	1.0a	1.0a	1.0a
Metolachlor	2.0	1.0a	1.0b	1.0b	1.0a	1.0a	1.0a	1.0a	1.0a	1.0a
Metolachlor	2.5	1.7a	1.0b	1.3ab	1.0a	1.0a	1.0a	1.0a	1.0a	1.0a
Pendimethalin	1.5	3.7a	1.6b	2.6ab	1.0a	1.0a	1.0a	1.0a	1.0a	1.0a
Pendimethalin	2.0	1.0a	2.7a	1.8ab	1.0a	1.0a	1.0a	1.0a	1.0a	1.0a
Pendimethalin	2.5	3.7a	2.3b	3.0a	1.0a	1.0a	1.0a	1.0a	1.0a	1.0a
Metolachlor +diuron	1.5+0.5	2.0a	1.0b	1.5ab	1.0a	1.0a	1.0a	1.0a	1.0a	1.0a
Metolachlor +diuron	2.0+1.0	3.0a	1.0b	2.0ab	1.0a	1.0a	1.0a	1.0a	1.0a	1.0a
Metolachlor +diuron	2.5+1.5	1.6a	1.3b	1.5ab	1.0a	1.0a	1.0a	1.0a	1.0a	1.0a
Pendimethalin+ diuron	1.5+0.5	3.3a	1.3b	2.3ab	1.0a	1.0a	1.0a	1.0a	1.0a	1.0a
Pendimethalin+ diuron	2.0+1.0	2.3a	1.7b	2.0ab	1.0a	1.0a	1.0a	1.0a	1.0a	1.0a
Pendimethalin+ diuron	2.5+1.5	2.0a	3.3a	2.7ab	1.0a	1.0a	1.0a	1.0a	1.0a	1.0a
Metolachlor +I SHW	2.0	2.0a	3.3a	2.7ab	1.0a	1.0a	1.0a	1.0a	1.0a	1.0a
Pendimethalin+ I SHW	2.0	1.3a	1.3b	1.3ab	1.0a	1.0a	1.0a	1.0a	1.0a	1.0a
Metolachlor + diuron+I SHW	1.5+0.5	1.7a	1.0b	1.3ab	1.0a	1.0a	1.0a	1.0a	1.0a	1.0a
Pendimethalin+diuron+ISHW	1.5+0.5	3.3a	1.3b	2.3ab	1.0a	1.0a	1.0a	1.0a	1.0a	1.0a
Weeding at 3 and 6 WAS	-	1.7a	1.0b	1.3ab	1.0a	1.0a	1.0a	1.0a	1.0a	1.0a
Weedy Check	-	1.7a	1.0b	1.3ab	1.0a	1.0a	1.0a	1.0a	1.0a	1.0a
SE(±)		0.24	0.12	0.02	0.11	0.0	0.00	0.0	0.0	0.00

I=Weeks after sowing 2=columns with the same letters are not significantly different at 5% level of probability according to Duncan's Multiple Range Test (DMRT) 3= Supplementary hoe weeding.

Table 4 : Influence of different methods of weed control on plant height of soybean, 2012 AND 2013.

Treatment	Rate kg a.i.lha	PLANT HEIGHT (cm^2) 6WAS			HARVEST		
		2012	2013	Mean	2012	2013	Mean
Metolachlor	1.5	26.5a	23.8ab	25.2ab	53.1a	37.7ab	45.4ab
Metolachlor	2.0	28.7a	25.2ab	26.9ab	49.9a	39.6ab	44.8ab
Metolachlor	2.5	25.9a	23.8ab	24.9ab	50.0a	40.1ab	45.1ab
Pendimethalin	1.5	25.6a	25.3ab	25.4ab	43.8a	43.9ab	43.9ab
Pendimethalin	2.0	28.2a	20.7bc	24.5ab	51.5a	28.1cd	39.8cd
Pendimethalin	2.5	20.9a	24.3ab	22.6bc	45.3a	39.1ab	42.2ab
Metolachlor + diuron	1.5+0.5	27.1a	25.7ab	26.4ab	48.6a	43.4ab	46.0ab
Metolachlor + diuron	2.0+1.0	23.5a	26.8a	25.1ab	47.7a	48.5ab	48.1ab
Metolachlor + diuron	2.5+1.5	28.5a	25.0ab	26.7ab	57.0a	40.1ab	48.6a
Pendimethalin+ diuron	1.5+0.5	25.5a	26.3ab	25.9ab	50.2a	40.6ab	45.4ab
Pendimethalin+ diuron	2.0+1.0	23.7a	23.3ab	23.5bc	45.0a	39.3ab	42.1ab
Pendimethalin+ diuron	2.5+1.5	27.2a	23.3ab	25.2ab	51.7a	32.7bc	42.2ab
Metolachlor +I SHW	2.0	23.4a	23.7ab	23.5ab	42.4a	38.1ab	40.3bc
Pendimethalin+ I SHW	2.0	23.8a	24.7ab	24.3ab	42.5a	37.8ab	40.1bc
Metolachlor + diuron+I SHW	1.5+0.5	29.6a	28.5a	29.1a	49.5a	50.7a	50.1a
Pendimethalin+diuron+ISHW	1.5+0.5	21.8a	23.5ab	22.7bc	44.2ab	43.1ab	43.7ab
Weeding at 3 and 6 WAS	-	23.9a	28.9a	24.5ab	48.8a	44.1ab	43.0ab
Weedy Check	-	20.1a	18.1c	21.0c	41.9a	24.5d	36.7d
SE(±)		0.71	0.31	0.05	1.03	1.15	0.09

I=Weeks after sowing 2=columns with the same letters are not significantly different at 5% level of probability according to Duncan's Multiple Range Test (DMRT) 3= Supplementary hoe weeding.

Table 5 : Influence of different weed control methods on soybean crop vigour, 2012 and 2013.

Treatment	Rate kg a.i./ha	CROP VIGOUR					
		6 WAS			9 WAS		
		2012	2013	Mean	2012	2013	Mean
Metolachlor	1.5	8.2a	8.0ab	8.1a	8.2a	7.5bc	7.8ab
Metolachlor	2.0	7.5a	8.2ab	7.8ab	8.2a	7.8ab	8.0ab
Metolachlor	2.5	7.5a	8.0ab	7.8ab	8.5a	7.2bc	7.8ab
Pendimethalin	1.5	7.2a	7.7ab	7.4ab	7.0a	7.0bc	7.0d
Pendimethalin	2.0	8.2a	7.0bc	7.6ab	9.2a	7.0bc	8.1ab
Pendimethalin	2.5	7.5a	7.2ab	7.3ab	7.3a	6.8c	7.1cd
Metolachlor + diuron	1.5+0.5	7.7a	8.3ab	8.0a	8.5a	8.0ab	8.3ab
Metolachlor + diuron	2.0+1.0	7.2a	8.5ab	7.8ab	7.7a	8.2ab	7.9ab
Metolachlor + diuron	2.5+1.5	8.2a	8.0ab	8.1a	8.7a	7.3bc	8.0ab
Pendimethalin+ diuron	1.5+0.5	7.8a	8.2ab	8.0a	8.5a	7.8ab	8.2ab
Pendimethalin+ diuron	2.0+1.0	7.3a	7.8ab	7.6ab	7.8a	8.0ab	7.9ab
Pendimethalin+ diuron	2.5+1.5	7.7a	6.3cd	7.0bc	8.3a	6.8c	7.6bc
Metolachlor +I SHW	2.0	7.5a	7.5ab	7.5ab	7.8a	7.7ab	7.8bc
Pendimethalin+ I SHW	2.0	7.3a	7.5ab	7.4ab	7.8a	7.3bc	7.6bc
Metolachlor + diuron+I SHW	1.5+0.5	7.3a	8.8a	8.1a	8.3a	9.2a	8.8a
Pendimethalin+ diuron+I SHW	1.5+0.5	7.2a	7.8ab	7.5ab	7.7a	7.5bc	7.6bc
Weeding at 3 and 6 WAS	-	7.5a	8.7ab	8.1a	7.5a	8.5ab	8.0ab
Weedy Check	-	7.8a	5.2d	6.5c	7.0a	4.3d	5.7e
SE(±)		0.10	0.16	0.01	0.15	0.16	0-01

I=Weeks after sowing 2=columns with the same letters are not significantly different at 5% level of probability according to Duncan's Multiple Range Test (DMRT) 3= Supplementary hoe weeding.

Table 6 : Influence of different methods of weed control on 100-seed weight and grain yield (kg/ha), 2012 and 2013.

Treatment	Rate kg a.i./ha	100-seed weight (g)			Grain Yield (kg/ha)		
		2012	2013	Mean	2012	2013	Mean
Metolachlor	1.5	13.3a	13.9de	13.6b	1764.7ab	239.8cd	1002.3bc
Metolachlor	2.0	13.1a	14.4bc	13.8ab	1759.7ab	255.5cd	1007.6bc
Metolachlor	2.5	13.6a	15.1ab	14.3ab	2427.2ab	283.2cd	1355.2ab
Pendimethalin	1.5	13.4a	15.3ab	14.3ab	1345.8bc	378.9cd	862.3cd
Pendimethalin	2.0	13.4a	13.7e	13.6b	2658.7a	208.1cd	1433.4ab
Pendimethalin	2.5	12.9a	14.0de	13.5b	1967.6ab	276.6cd	1122.1ab
Metolachlor + diuron	1.5+0.5	13.1a	14.3bc	13.7b	1893.3ab	285.5cd	1089.7bc
Metolachlor + diuron	2.0+1.0	13.0a	14.4bc	13.7b	1961.3ab	481.6bc	1221.5ab
Metolachlor + diuron	2.5+1.5	13.6a	14.2bc	13.9ab	1946.8ab	331.8cd	1139.3ab
Pendimethalin+ diuron	1.5+0.5	13.6a	14.7ab	14.1ab	2384.0ab	393.1cd	1388.5ab
Pendimethalin+ diuron	2.0+1.0	13.6a	14.7ab	14.1ab	1835.4ab	556.6bc	1196.0ab
Pendimethalin+ diuron	2.5+1.5	13.6a	14.2cd	13.9ab	2340.9ab	268.5cd	1304.7ab
Metolachlor +I SHW	2.0	13.4a	14.5bc	14.1ab	2585.6a	606.6bc	1596.1ab
Pendimethalin+ I SHW[3]	2.0	13.5a	14.7ab	14.1ab	2320.2ab	447.7bc	1384.0ab
Metolachlor +diuron+I SHW	1.5+0.5	13.7a	15.8a	14.7a	2397.8ab	1013.1a	1705.4a
Pendimethalin+ diuron+I SHW	1.5+0.5	13.1a	15.5ab	14.2ab	2320.0ab	560.5bc	1440.2ab
Weeding at 3 and 6 WAS	-	13.3a	15.3ab	14.2ab	2345.5ab	803.7ab	1574.6ab
Weedy Check	-	13.3a	13.9de	13.5b	623.6c	108.2d	365.9d
SE(±)		0.10	0.11	0.01	86.48	37.71	6.69

I=Weeks after sowing 2=columns with the same letters are not significantly different at 5% level of probability according to Duncan's Multiple Range Test (DMRT) 3= Supplementary hoe weeding.

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Economic Analysis of Constraints Faced in Adoption on Sample Dairy Farms in Bikaner District of Rajasthan

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Raju Kumawat [α], N.K. Singh [σ] & Chiranjee Lal Meena [ρ]

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I. Introduction

One of the most significant changes in India's agricultural economy over the past three and half decades has been the rising contribution of livestock sector in the agricultural gross domestic product (Ag.GDP). Between 1970 and 2008, the share of livestock in Ag GDP has risen from 17 per cent to 29 per cent. Dairying accounts for more than two-third of the live stock output and is largely responsible for the rising importance of the livestock sector in the country. India has emerged as the world's largest milk producer and milk producing continues to grow at a fairly high rate.

The Indian dairy cooperative system is one of the biggest in the world consisting of more than 74,000 primary dairy societies with a membership of above 10 million milk producers and providing a reliable marketing service to all milk producers irrespective of their class, caste, economy of scale through the country. It also provides basic dairy extension services such as Supply of cattles feed, fodder seed, animal health services, artificial insemination for both cattle and buffaloes to the members of dairy cooperative societies *(Sasikumar, 1998).*

Livestock forms an integral part of rural India. Farmers not only produce food grains but also manage Livestock. Farmer's income, agriculture and rural economy are heavily dependent on livestock. Infact livestock is a major instrument of production of small farmers. India has the largest cattle population in the world. Almost every rural household in India, whether landed or landless, owns livestock. The livestock population of India is around 535 million comprising of 199 million cattle, 105 million buffaloes, 140 million goats, 71 million sheep and 11 million pigs and ranks first in buffalo while second in cattle and goat population [11]. Of the total livestock in the country, around38.2% are cattle, 20.2% are buffaloes, 12.75 are sheep, 25.6% are goats and only 2.8% are pigs. India has a large genetic diversity of livestock containing 26 breeds of cattles, 8 breeds of buffaloes, 40 breeds of sheep, 20 breeds of goats and 7 breeds of camels. The country has 13 percent of world's cattle population and 57% of world's buffalo population. The milk production in the country is 112 million tonnes mainly being contributed by199 million cattle and 105 million buffaloes. However, average milk yield at 300 Kg per lactation is bysmally low. The per capita availability of milk in our country is 252g/day. The biggest threat is the milk productivity. Despite having the world's largest population the milk productivity per animal comes to 987 Kg/year whereas worldwide average productivity is 2200 Kg per animal per year [12]. The gradual breed deterioration generally occurs from negligence over centuries and consequent rise in the population of nondescript cows (80 %) and buffaloes (50%) along with the chronic shortage of feed and fodder coupled with their nutritive values and low fertility of our dairy animals has resulted in the low productivity [9].

Indian Agriculture has been the main stay of Indian economy as 64 per cent of the population depends on it. This sector plays a crucial role in the economic development of the country. At present Agriculture and allied sector contribute nearly 14.6 per cent of country's GDP at 1999-00 prices. Dairying in India occupies a prominent place in rural life and

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provides not only subsidiary occupation and nutritional standards but is also a source of organic manures and draught power. Livestock sector contributes about 4.0 per cent of the total GDP and 23 per cent of the agricultural GDP in the year 2008-09. Milk is an important commodity not only as a source of dairy industrial raw material but also a nutritive food for the people. Milk has been considered nearly a complete food for the infants and growing children. In the year 2009 the country projected human population was 1145 million while milk production was 108.5 Mt making a per capita availability of 258 g per day against 265 g per day per capita recommended by World Health Organization (WHO).

The input–output relationship in milk production has been studied and the compared comprising cost of milk production is fairly well established. These components are feed, labour, capital, cost of animals, and cost of technical input.

India is the 'Oyster' of the global dairy industry. As India enters an era of economic reforms in general and agriculture particularly the livestock sector is positioned to be a major growth area. The fact that dairying could play a more constructive role in promoting rural welfare and reducing poverty is increasingly being recognized, e.g., milk production alone involves more than 70 million producers, each raising one or two cows/ Buffaloes. Cattle also serve as an insurance cover for the poor households, because they can be sold during times of distress. The need for food items especially for milk and product in India is increasing rapidly due to several factors like increasing population, urbanization, income levels, awareness about nutritive value and also the changes in tastes and preferences. The World Bank study has projected the demand for milk in India at 350 million tones by 2020. It has been observed in the FAO Evaluation Committee report that dairy development in India offers a unique advantage over industrialization or crop husbandry development. This premise is based on the spread effect of dairy development, which is more evenly distributed as compared to the other two alternatives because it specially benefits the weaker sections. Most of the cultivating households, irrespective of the size of their land holding, own their milch animals. Cattle rearing continue to be an integral part of Indian agricultural scene. Milk production in the country was stagnant during the 1950s and 1960s; annual production growth was negative in many years. The annual compound growth rate in milk production during the first decade after independence was about 1.64 per cent, during the 1960s, this growth rate declined to 1.15 per cent. During the late 1960s, the Govt. of India initiated major policy changes in the dairy sector to achieve self- sufficiency in milk production. Producing milk in rural areas through producer cooperatives and moving processed milk to urban demand centers become the cornerstone of the government dairy development policy. This policy initiative gave a boost to dairy development and initiated the process of establishing the much–needed linkages between rural producers and urban consumers.

In global context, the performance of the Indian dairy sector appears impressive in term of livestock population and total milk production but extremely poor in term of productivity. The average milk productivity per year per cow increased from 731 kg in 1989-91 to about 1,044.10 kg in 1999. Although average annual milk production per animal has improved substantially, it is far below the world average (2071 kg per year) and that of countries such as Israel (8785 kg), the United States (8,043 kg) and Denmark (6565kg). The available data on milk yield indicate that average productivity went up substantially in the case of cows during the 1970s and 1980s. There is an increase in the yield of buffaloes also, but it is less sharp than that of cows. A key factor accounting for the sharper increase in cow milk yield is the increasing proportion of crossbred cows.

As in milk production and availability, there are wide inter-state variations in milk yields. In general, buffaloes have higher yields than indigenous cows, but crossbred cows are more productive than either indigenous cows or buffaloes. In 2000-01, the average productivity of local cows is highest in Haryana. The Indian dairy industry is poised for dramatic growth in the coming decades. The population growth, urbanization, income growth, high income elasticity of demand and changes in food habits that fuelled the increase in milk consumption are expected to continue well into the new millennium, creating a veritable livestock revolution, environmental sustainability, public health and ethical concerns about the treatment of animals.

Indian Arid zone, where livestock rearing is generally main occupation of rural masses, consists of 12 per cent of country's geographical area and 61 per cent of India's arid zone is Rajasthan. Climate of this zone is not suitable for crop rising. Annual rainfall here is below 300 mm per year, that too irregular during monsoon season, which often leads to wide spread drought conditions. The milk production is influenced to a great extent by the feeding pattern, the quality of feed and the ingredients in the feed. The feeds and fodder accounts for 50 to 75 per cent of the total cost depending upon the condition under which the milch animals are kept for milk production. Feed consists of green fodder, including pasture grass and tree lopping, dry fodder, concentrates and balanced cattle feed. During the 1950s and 1960s, India was one of the largest importers of dairy products, importing over 40 per cent of milk solids in dairy industry. The commercial import of milk powder reached its peak at about 53 thousand tonnes in 1963-64 (Kannitkar, 1999). This caused alarm to policy makers and a decision was made to achieve self-sufficiency in milk production. The major step forward, came in mid-sixties with the establishment of the National Dairy Development Board (NDDB) to see over dairy development in the country. The Operation Flood Program, one of the world's largest and most successful dairy development programmers, was launched in 1970. Its main thrust was to organize farmers' cooperatives in rural areas and link them with urban consumers. Operation Flood has led to the modernization of India's dairy sector and has created a strong network for procurement, processing and distribution of milk by the cooperative sector. In 1989, the Government of India launched the Technology Mission on Dairy Development (TMDD) program to support and supplement the efforts of Operation Flood and to enhance rural employment opportunities and income generation through dairying.

There are large inter-regional and inter-state variations in milk production as well as per capita availability in India. About two–third of national milk production comes from Utter Pradesh, Punjab, Rajasthan, Madhya Pradesh, Maharashtra, Gujarat, Andhra Pradesh and Haryana. However, there have been some shifts in milk production share of different states. In 2007-08, U.P. was the largest milk producer in the country with about 18.8 Mt of milk, followed by Rajasthan (9.95 Mt), Punjab (9.3 Mt), M.P. (6.1 Mt), Maharashtra (6.0 Mt) and Gujarat (5.6 Mt). Major milk producing regions in country have good resource endowment and infrastructure. The eastern region is lagging behind in term of dairy development. The average per capita availability of milk during 2007-08 was highest in Punjab (962 g per day), followed by Haryana (632 g per day), Rajasthan (408 g per day). The average per capita consumption of milk and dairy product is lowest in rural areas than in urban areas, even though milk is provide by rural areas. Rajasthan state occupies third rank (9.49 Mt) next only to Uttar Pradesh and Andhra Pradesh in milk production in the country and fourth rank (399 g per day) next only to Punjab, Haryana and Gujarat in per capita per day milk availability in 2008-09. The state has 6.6 per cent of cows and 7.18 per cent of buffaloes of the total in the country and contributes about 9 per cent of the total milk production.

Thus study was undertaken to find out profitability of milk production, feeding pattern, supply pattern and adoption of scientific management practices for milch animals in Bikaner district of Rajasthan. The specific objectives of the study are

1. To study investment, feeding and milk supply patterns on sample dairy farms.
2. To study the cost and returns of milk production on sample farms and,
3. To study the extent of adoption of recommended management practices and constraints faced in adoption on sample farms.

II. Material and Methods

Bikaner district of Rajasthan was selected purposively. The paper was exploratory in nature and primarily aims to know the investment, feeding and milk supply patterns, cost and returns of milk production, recommended management practices and constraints. For the selection of dairy farms, a complete list of all dairy farms operating in Bikaner was obtained and five dairy farms having herd size of more than 20 milch animals were selected randomly. The primary data were collected through personal interview method on pre-structured and pretested schedules from selected dairy farms for the year 2010-11. The collected data regarding cost components, milk production, consumption, investments and marketed surplus etc. were analyzed by using simple tabular analysis, averages, percentage and ratios. The cost and returns analysis was carried out on the basis of different cost concepts as given below:-

a) *Analysis of data*

i. *Analytical techniques*

a. Cost and Returns Analysis:

The cost and returns analysis was carried out on the basis of different cost concepts as given below:-

ii. *Constraints in adoption recommended management practices:-*

The following recommended practices were taken into consideration to find out the adoption in the dairy management. The package of recommended management practices was obtained from College of Veterinary and Animal Sciences, Bikaner.

a. *Feeding:*

1. Feeding of concentrate
2. Feeding of dry fodder
3. Feeding of green fodder
4. Feeding of salt

b. *Management:*

1. Cleaning of animals
2. Housing facility
3. Tattooing (For identification number on the milch animals by using scientific method)
4. Dehorning (Removal or check the horns at heirfer stage)
5. Hoof trimming (Cutting of hoof for prevention of overgrowth of hoofs. It keep animal fit for walk, prevents weakness of legs)

c. *Breeding:*

1. Artificial insemination

d. *Health practices:*

1. Vaccination (For protection to animal from diseases and to maintain the health)

2. Deworming (Controlling the endo-parasite of animals through oral supply and by mixing in the drinking water).
3. Treatments

e. Milking:

1. Cleaning of animals and milking site
2. Cleaning of milking equipments
3. Method of milking

f. Marketing of milk:

1. Storage facilities
2. Supply of milk
3. Price of milk
4. Payment received

III. Results and Discussion

In this section socio-economic profile of the sample households has been described. The socio-economic characters of dairy owners have a profound influence on the decision-making process and profitability of dairy enterprise. The important socio-economic characters are presented below:

The occupational distribution of sample households is shown in Table 1. It was observed that 50 per cent family members are dependent are not involved in any occupational work. Among other family members those are engaged in occupational work were recorded 50-50 per cent in dairying activities and other work respectively. Therefore, only 25 per cent families were associated with dairying.

a) Occupation

Table 1 shows the total number of cattle maintained, milch animals maintained, Number of milch animals maintained at different dairy farms. The table reveals that out of total 280 animals, 155 were milch and 125 were calves. On an average, each dairy farm had 56 animals. Out of which 31 were milch and 25 were calves. In general, each dairy farm had 55.35 per cent milch animals, with 44.64 per cent calves. The number of cattle maintained by dairy owner's recorder varied from 34 to highest 84 , out of 155 total milch animals, there were 8 buffaloes, 30 local, 71 Holstein Friesian and 46 Jersey cows.

On an average, each dairy farm had 31 total milch animals out of which the number of Holstein Friesian cow was found highest (45.80 per cent) in all milch animals. The next more popular cow maintained by dairy owners was Jersey (29.69 per cent). However; Buffalo was maintained by only 5 per cent of dairy owners.

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Table 1 : Occupational distribution of sample house holds & animals maintained at different dairy farms .

Dairy farm	Total no. of family members	Working			Dependent	No. of Animals			Number of milch cows and buffaloes maintained				
		Dairying	Other	Total		Milch	Calves	Total	Buffaloes	Local cows	Holstein Friesian	Jersey	Total
1.	6	2	1	3	3	21	13	34		5	9	7	21
2.	8	2	2	4	4	45	39	84	3	12	18	12	45
3.	5	1	2	3	2	25	20	45		4	12	9	25
4.	6	1	1	2	4	29	31	60		6	15	8	29
5.	7	2	2	4	3	35	22	57	5	3	17	10	35
Total	32	8	8	16	16	155	125	280	8	30	71	46	155
Average	6.25	1.6	1.6	5.33	5.33	31	25	56	4	6	14.2	9.2	31
%	100	25	25	50	50	55.35	44.64	100	5.16	19.35	45.80	29.69	100

In this section socio-economic profile of the sample households has been described. The socio-economic characters of dairy owners have a profound influence on the decision-making process and profitability of dairy enterprise. The important socio-economic characters are presented below:

a) Adoption and Constraints

Adoption of scientific practices in rearing of milch animals by different dairy farms.

The rearing and performance of milch animals is directly associated with the various operational methods employed. The scientific practices recommended by experts play an important role in increasing the milk production efficiency of animals. Therefore, to know whether the dairy owners are adopting the recommended scientific practices for their milch animals, the essential information regarding adoption of various scientific practices were collected from the dairy owners and the collected data were analyzed and results are presented in Table 2. It is discussed in detailed under the following sub-heads.

i. *Feeding practices*

The adoption of scientific feeding practices by dairy owner in respect of concentrate, green fodder and dry fodder, as observed from the table reveals that no any dairy owners supplied concentrate to their milch animals as per recommended by experts. However, partially adopted the recommended quantity of concentrate was by 60 per cent dairy owners and 40 per cent dairy owners identified as non-adopter of scientific feeding practices recommended for concentrate. In respect of green fodder 100 per cent dairy owners adopting the scientific feeding practices partially due to one or other reasons. In the average most of the dairy owners (100 per cent) in the area were fully adopting the watering practices and fully adopting the feeding practices for dry fodder. Salt supplied by dairy owner to their milch animals were recorded 100 per cent fully adopted.

ii. *Management practices*

Under the management practices, several scientific practices suggested by veterinary doctors are given in Table 2. In the table it can be seen that cleaning of the animals and animals sheds was the major operation and generally adopted partially by 40 per cent and 70 per cent dairy owners.

Table 2 : Adoption of recommended management practices by different dairy farms.

S. No.	Scientific practices	Fully adopted	Partially adopted	Not-adopted
1.	Feeding			
	a. Concentrates	-	60	40
	b. Dry fodder	100	-	-
	c. Green fodder	-	100	-
	d. Salt	100	-	-
	e. Watering	100		
2.	Management			
	a. Cleaning of animals	60	40	-
	b. Cleaning of animal shed	30	70	-
	c. Housing facilities	-	70	30
	d. Tattooing	-	-	100
	e. Dehorning	-	-	100
	f. Hoof trimming	-	-	100
3.	Breeding			
	a. Artificial insemination	-	-	100
4.	Health practices			
	a. Vaccination	-	40	60
	b. Dewarming	80	20	-
	c. Treatments	40	60	-
5.	Milking			
	a. Cleaning of milch animals and milking site before milking	45	55	-
	b. Cleaning of milking equipments	80	20	-

(Percentage)

* *Fully adopted: - Recommended practices adopted more than 75 percent by dairy owners.*
* *Partially adopted: - Recommended practices adopted up to 75 percent by dairy owners.*
* *Not adopted: - Recommended practices not adopted by any dairy farm.*

Fully adopted practices were recorded on any dairy farms 60 and 30 per cent in these two management practices. In respect of housing for milch animals, it was found that all dairy owners not having the housing facilities for their milch animals as per recommended by veterinarian only 70 per cent adopted partially and 30 per cent was not adopted. Further, the recommended tattooing practice was taking by 100 per cent dairy owners not adopted the recommended practice. Dehorning and hoof trimming were not adopted by any dairy owners.

iii. *Breeding practices*

During the investigation, it was noticed that all dairy owners were more confident on natural breeding. Thus artificial breeding practices were not taken regularly by any dairy farms. However, when they feel necessary for individual milch animal they taken to their animal for artificial insemination in the centre where this facility available.

iv. *Health Practices*

In respect of health care, the vaccination, deworming and treatments are the most important operational activities as recommended by specialist for keeping the animals healthy and in better performance. It can be observed from the table 4.25 that the deworming was the major health care activity and adopted fully by 80 per cent dairy owners in the area and only 20 per cent dairy owners adopted this management practice partially. In other health care practices treatment of milch animals was exercised by all dairy owners in fully (40 per cent) and partially (60 per cent).

Vaccination in milch animals was not a common practice as it was partially adopted only by 40 per cent dairy owners and 60 per cent dairy owners are not conscious about Vaccination to their milch animals.

v. *Milking*

Cleaning of milch animals and cleaning site where milking is taking place was partially adopted 55 per cent and 45 per cent fully adopted by all dairy owners dairy owner as recommended by experts. Cleaning of milking equipments were found common in practice before milking of milk 80 per cent dairy owners cleaning their milking equipment fully and 20 per cent partially as recommend by experts.

b) *Constraint in adoption of Scientific practices by dairy farms*

It was observed that number of problems is faced by dairy owners, regarding maintenance of their milch animals. Some important problems generally facing the dairy owners are related to the inadequate feeding, health care and management practices. These problems are directly associated with the performance of the milch animals. Due to various reasons, dairy owners could not maintain their milch animal as per recommended scientific practices. The reasons which are creating there problem in adopting the scientific practices are considered as constraints and the major constraints are presented in Table 3 and discussed below:

Table 3 : Constraints in adoption of recommended management practices by dairy owners.

S. No.	Constraints		Percentage
1	Feeding of concentrates		
	1.	Feed cost is very high	60
	2.	Not aware about recommended quantity	40
2	Feeding of green fodder		
	1.	Not available sufficiently in the area for purchasing	100
3	Management practices		
	A. Housing facilities		
	1.	Lack of sufficient space	60
	2.	Not aware about recommended practices	40
	B. Dehorning		
	1.	Not aware about scientific methods	80
	2.	Proper equipments and chemicals are not available	20
	C. Tattooing		
	1.	Not much aware about these practices	
	2.	Don't feel necessary	20
	D. Hoof trimming		80
	1.	Lack of awareness and don't feel necessary	100
4	Artificial Breeding		
	1.	More confident in natural breeding	20
	2.	Method is complicated	80
5	Health practices like Vaccination, Deworming and Treatments		
	1.	Lack of facilities	
	2.	Lack of awareness	60
			40

i. *Feeding of concentrates*

It was observed that 100 per cent dairy owners are facing the problems related the inadequate supply of concentrate against the quantity recommended by specialist. Among these dairy owner, 60 per cent dairy owners were unable to supply the adequate concentrates quantity to their milch animals due to higher concentrates cost and 40 per cent dairy owners not given importance about recommended quantity of concentrates to be supplied to their milch animals.

ii. *Feeding of green fodder*

During the collection of information from sample dairy owners regarding feeding of green fodder, it was noticed that, the supplying of green fodder to the milch animals was very less in quantity especially in summer season due to one or another reasons. The major constraints was observed that no sufficient quantity of green fodder available in the area for purchasing as per dairy owners requirement and 100 per cent dairy owners were facing this problem.

c) *Management practices*

i. *Housing facilities*

Sufficient space and other housing facilities playing the important role in maintaining the health and production efficiency of milch animals but due to some constraints, dairy owners were unable in adopting the housing facilities to their milch animals as per recommended by experts. The majority of the dairy owners were having the constraints of insufficient space in their dairy farms as per required for per milch animals. However, some of the dairy owners not given the importance of recommended housing facilities.

ii. *Dehorning*

Dehorning of milch animals was not in a common practice in the dairy farms due to two reasons. Firstly, due to lack of awareness about scientific method of deworming and secondly, due to lack of availability of proper equipments, chemicals etc. The majority of dairy owners 80 per cent identified as they were not aware about scientific method of dehorning and only 20 per cent dairy owners wants to adopt the dehorning practices but due to lack of proper equipment, chemicals and other required facilities, the dehorning practices was not adopted by dairy owners.

iii. *Tattooing*

Tattooing practice of the animals was not a common practice on all the dairy farms, 20 per cent dairy owners not much aware about this practice and 80 per cent dairy owners don't feel necessary of this practice.

iv. *Hoof trimming*

Hoof trimming by scientific methods is one of the important practices for health point of view but this practice was not a common and no any dairy owner was adopting this practice due to lack of awareness and don't feel necessary.

v. *Artificial breeding*

Regarding the adoption of breeding practices in scientific manner, no any dairy owner was identified as a adopter and the major constraints was observed, that they are more confident in natural breeding and feel complicated of this method. No artificial breeding facilities were available with the dairy owner at their dairy farms.

d) *Health practices like Vaccination, Deworming and Treatments*

The health practices manly not adopted by dairy owners due to lack of facility and lack of awareness, about 60 per cent dairy owners facing these problems due to lack of facility and 40 per cent due to lack of awareness.

IV. Conclusion

The selection of dairy farm was done randomly. As a whole, five dairy farms were selected, having herd size of ≥ 20 milch animals.

The study revealed that there was constraints for the lack of management practices adoption were non availability of green fodder inadequate quantity for purchasing, high cost of feed and fodder, lack of insufficient space in dairy farms, lack of awareness, among all dairy owners about scientific management practices and some dairy owners feel not necessary about management practices. Most of the dairy owners were practicing scientific management practices such as feeding of green fodder, cleaning of animals and animal shed and health practices adopted partially and few management practices such as dry fodder, salt and watering, deworming and treatment were adopting fully and totting, dehorning, hoof treaming, artificial insemination and vaccination practice were not adopted by majority of dairy owners.

V. Conclusions

1. The results of the study clearly indicated that the highest investment was made on milch animals especially on Holstein Friesian cow by all dairy owners.
2. Most of the dairy owners were practicing scientific management practices such as feeding practices, cleaning of animals and animal's sheds, grooming, health practices partially very few management practices such as watering, deworming and treatments were adopting fully by dairy owners. However, some practices like housing facilities, tattooing, dehorning, hoof trimming artificial insemination, were not adopted at any level by dairy owners. The major constraints for lack of management practices adoption were non

availability of green fodder in adequate quantity for purchasing, high feed cost, lack of awareness and not feel necessary, lack of facilities.

VI. Recommendations

1. There is need to motivate dairy owners for adoption of scientific management practices in rearing of milch animals for better health and performance.
2. In the context of various production traits Holstein Friesian and Jersey cows were more superior than buffalo and local cows. Hence, emphasis should be given towards increasing herd strength with these breeds.
3. There is an imperative need to give recommended doses of feed and fodder to increase milk production.
4. Looking to the average milk production of cows and buffaloes, it is recommended that better breeding practices should be made available to the milk producers of the study area so that milk yield can be improved.

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Morphomeric Variability among Samples of *Callosobruchus Subinnotatus* (Pic) (Coleoptera:Chrysomelidae) in Northwestern Nigeria

By Magaji B.T., Dike M.C., Onu I. & Kashina B.D.

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Abstract- Morphometric studies aimed at identifying some existing variations among different samples of Callosobruchus subinnotatus (Pic) collected from three locations each of five Northwestern States (Kaduna, Zamfara, Kebbi, Kano and Katsina) in Nigeria was evaluated. Thirteen diagnostic features were used in which measurements were carried out on ten characters using handheld digitalized Miscope microscope (40-140x magnification) while three ratios were used as explanatory variables. Data obtained were analyzed using the parametric statistical tools of mean, standard deviation and standard error. The distribution and relationships among samples studied were expressed using two step cluster analysis, results of which were drawn into cluster distributions, centroids of means of morphoclusters and the simultaneous confidence intervals (95%) used to determining the level of significance among measured variables of the samples. The result gave two morphoclusters revealing the existence of two possible races of C. subinnotatus in Northwestern Nigeria. Race 2 constituted the highest percentage distribution across the States with 53.3% against race 1 with 46.7%. Race 2 were relatively bigger in size than race 1.

Keywords: *callsobruchus subinnotatus, morphoclusters, races, centroids, diagnostic features.*

GJSFR-D Classification : *FOR Code: 079999*

MORPHOMERICVARIABILITYAMONGSAMPLESOFCALLOSOBRUCHUSSUBINNOTATUSPICCOLEOPTERACHRYSOMELIDAEINNORTHWESTERNNIGERIA

Strictly as per the compliance and regulations of :

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Keywords: callsobruchus subinnotatus, morphoclusters, races, centroids, diagnostic features.

I. Introduction

Many members of the subfamily Bruchinae are closely related morphologically but may have unique geographical distributions, life histories and ecological relationships. Sometimes, a population will physically alter over time to suit the needs of its environment and thus, can make members of the same species look different (Anon., 2011). Polymorphism is common among Bruchinae populations as previously described for C. *maculatus* (Fabricius) and C. *chinensis* Linnaeus in which adults were separated into 'normal' and 'active' morphs. *Callosobruchus subinnotatus* (Pic) is a primary field-to-store pest of bambara groundnuts only in West Africa, although its host *Vigna subterranea* (L.) Verdcourt is grown throughout the arid zones of Africa and parts of Asia but little is currently known about its biology, morphs or how it may be controlled (Appleb and Credland, 2001). The morphological significance of some major diagnostic characteristics of C. *subinnotatus* is being investigated to see the variability that exists among samples collected in different ecological zones of Northwestern Nigeria.

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II. Materials and Methods

a) *Sampling Sites and Culturing of C.subinnotatus*

Samples were collected from three locations each of Kebbi (Birnin Kebbi, Kangiwa and Zuru), Kaduna (Kagarko, Kaduna South and Giwa), Kano (Danbata, Gaya and Kano), Katsina (Bakori, Charanchi and Daura) and Zamfara (Gusau, Kaura Namoda and Talata Mafara) States of Northwestern Nigeria. Cultures of adult bruchids were raised in 1- litre capacity, clear plastic containers (9 cm diameter, 16 cm high) with 8 cm diameter screw- type lids. Each container contained about 200 g seeds of a susceptible bruchid host (cowpea (*Vigna unguiculata* (Walp)), bambara groundnut (*Vigna subterranea* (Bandare and Saxena, 1995). The lid of each container had a central circular perforation (3 cm diameter) covered with fine muslin cloth for aeration. These were kept under laboratory conditions and observed daily until adult emergence. The lid and side walls of the container with active species were tapped repeatedly so that the adults gathering around the lid or the side walls dropped back unto the seeds and chilled by refrigeration.

The newly -emerged bruchinae were sieved and transferred into vials (7.5 cm high and 2.5 cm diameter) containing 70% ethanol until use. *C. subinnotatus* was identified by the use of keys on adult morphological characters (Southgate, 1958; Haines, 1991) and comparison with preserved specimens in the reference collections of the Insect Museum of Crop Protection Department, Ahmadu Bello University Zaria where the research was conducted.

b) *Morphometrics*

Five pairs of C. species each per location were randomly subinnotatus selected and subjected to morphometric studies. Diagnostic features used by Southgate et al., (1957) and Kingsolver (2004) which are

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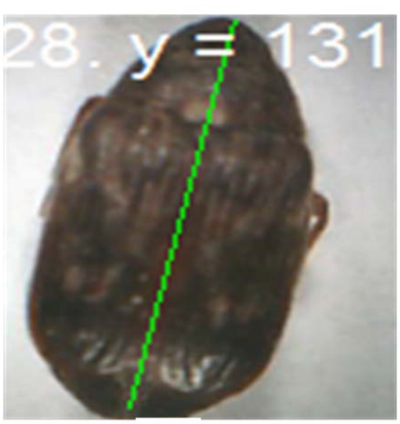
now consistently used in bruchids classification and comparison were adopted. A total of (13)diagnostic characters were used in which measurements were carried out on ten and three ratios were used as explanatory variables.

c) *Measurements of Diagnostic features and their codes*

i. Body length (bl) was measured from the anterior margin of pronotum to apex of abdomen (Plate a).
ii. Body width (bw) was measured across greatest width of elytra (Plate b).
iii. Eye width (ew) was measured across greatest width of eye (Plate c).
iv. Distance between eyes (dbe) was measured across the narrowest distance between eyes (Plate d).
v. Antennal length (al) was measured when antenna was fully extended with head in hypognathous position and covered the distance from the socket at base of antennal scape to apex of last abdominal segment (Plate e).
vi. Hind femoral width (hfw) was measured across greatest width of hind femur (Plate f).
vii. Width of coxa (wc) was measured across greatest width of coxa (Plate g).
viii. Length of pronotum (lp) was measured centrally from the anterior margin to the base margin of pronotum (Plate h).
ix. Width of pronotum anterior (wpa) was measured across the narrowest width of pronotum anterior (Plate i).
x. width of pronotum base (wpb) was measured across the greatest width of pronotum base (Platej).

All measurements were made in pixels using a calibrated handheld digitalized MiScope microscope. Values obtained were converted to millimeter using a factor 2.54/DPI (Dots per inch). For instance, if the measured pixel value is 45, then the millimeter equivalent will be 45x 2.54/300 =0.39 mm (DPI for computer screen is 300) (Dallin, 2008).

Plate's a-j: Measurements of diagnostic features



a

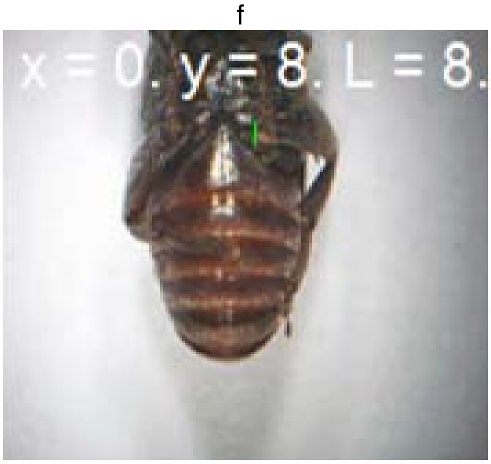
b

c

d


e

f



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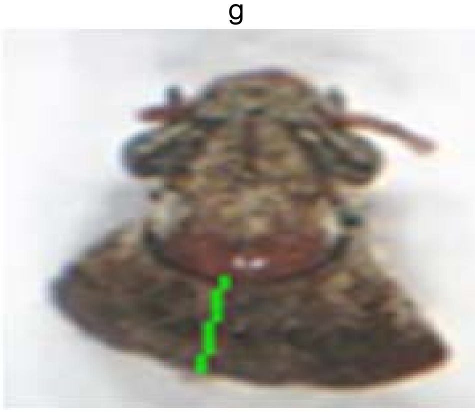

h

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j

III. Results

Cluster analysis on morphor data obtained from *C. subinnotatus* in Northwestern Nigeria gave two morphoclusters with morphocluster 2 having the highest percentage distribution across the States (53.3%) than morphocluster 1 (46.7%) as shown in table 1 below.

Table 1 : Morphocluster Distribution of *C. subinnotatus* in Northwestern States of Nigeria.

	Clusters	N	% of Combined	% of Total
	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]
Total		[illegible]		[illegible]

Distribution of the species among states studied showed that morphocluster 1 was recorded in all locations of Kebbi and Kaduna States as well as Charanchi (CRC) in Katsina State (100%) in the Northern Guinea savannah whereas morphocluster 2 were recorded in all locations of Zamfara and Kano States as well as Bakori and Daura locations of Katsina State in the Sahel zone as illustrated in Table 2.

Table 2 : Morphocluster Percentage of States of C. subinnotatus in Northwestern Nigeria.

Clusters	KBBK		KBKGW		KBZR		KDGW		KDKGK		KDKS		KNDBT		KNGY		KNKN	
	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%
1	10	100	10	100	10	100	10	100	10	100	10	100	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	10	100	10	100	10	100
Combined	10	100	10	100	10	100	10	100	10	100	10	100	10	100	10	100	10	100

Clusters	KTBKR		KTCRC		KTDR		ZMGS		ZMKND		ZMTMF	
	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%
1	0	0	10	100	0	0	0	0	0	0	0	0
2	10	100	0	0	10	100	10	100	10	100	10	100
Combined	10	100	10	100	10	100	10	100	10	100	10	100

Key

KBBK -Kebbi State – Birnin Kebbi
KBKGW - Kebbi State – Kangiwa
KBZR - Kebbi State – Zuru
KDGW - Kaduna State – Giwa
KDKGK – Kaduna State – Kagarko
KDKS - Kaduna State – Kaduna South
KNDBT – Kano State – Danbata
KNGY – Kano State – Gaya
KNKN - Kano State – Kano
KTBKR – Katsina State – Bakori
KTCRC – Katsina State - Charanchi
KTDR - Katsina State - Daura
ZMGS - Zamfara State - Gusau
ZMKND – Zamfara State – Kaura Namoda
ZMTMF – Zamfara State – Talata Mafara

Centroids of C. *subinnotatus* morphoclusters based on morphometric studies are shown in Figure 1. The result revealed that morphocuster 2 had higher centroid mean values at bl (4.74 mm), bw (2.40), hfw (0.73), lp (1.14 mm), wpa (0.75 mm) and wpb (1.60, mm) measurements as against 4.71 mm, 2.27 mm, 0.50 mm, 1.02 mm, 0.65 and mm, 1.35 mm on the same parameters of morphocluster 1 respectively. Conversely, morphocluster 1 had higher mean values at ew (0.51 mm), dbe (0.25 mm) and al (2.25, 2.05 mm) measurements than morphocluster 2.

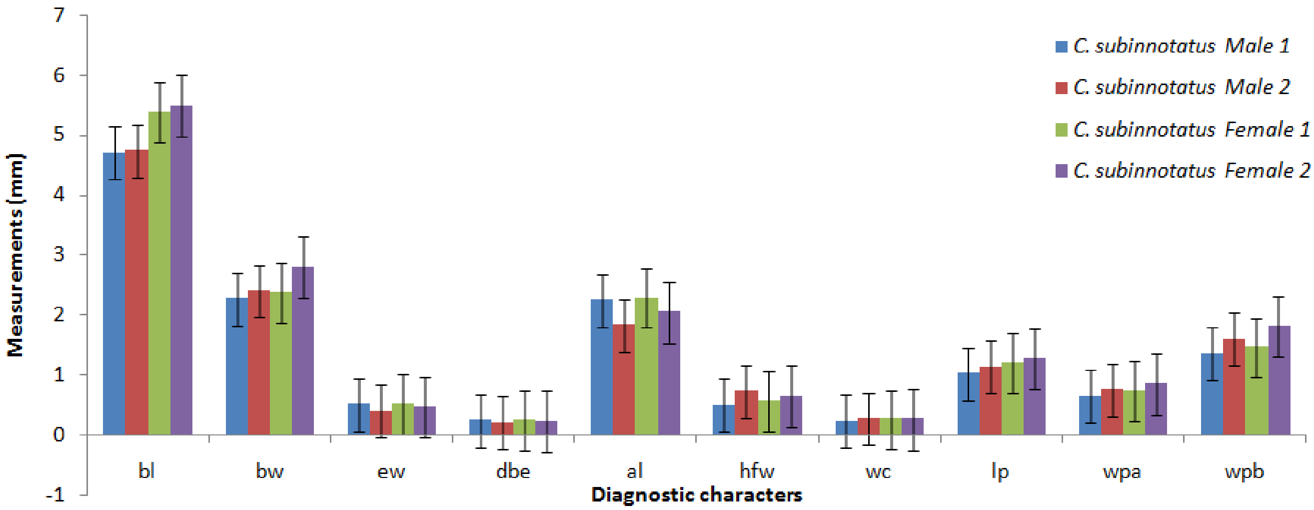


Figure 1 : Centroids derived from Cluster analysis of different variables of male and female Callosobruchus subinnotatus specimens collected from different locations in Northwestern Nigeria.

Key

bl – Body length
bw – Body width
ew – Eye width
dbe – Distance between eyes
al – Antennal length
hfw – Hind femoral width
wc – Width of coxa
lp - Length of pronotum
wpa – Width of pronotum anterior
wpb – Width of pronotum base

The within cluster variation simultaneous 95% confidence intervals of morphometric features showed that the means and mean ranges of bl, bw, hfw, lp, wpa and wpb in morphocluster 2 were significantly (P<0.05) higher than the same parameters in morphocluster 1 and the overall means. Conversely, morphocluster 1 were significantly (P<0.05) higher than the overall means and morphocluster 2 mean value at, ew, ew: dbe, as shown in Figures 2a-m below. For instance, bl of morphocluster 2 with mean value 4.74 mm ranging between 4.56-4.90 mm was significantly (P<0.05) higher than the mean of morphocluster 1 (4.71 mm, ranged 4.57-4.87 mm) and above the overall mean (4.72 mm). Similarly, bw of morphocluster 2 (2.40 mm, ranged between 2.33-2.45 mm) was significantly (P<0.05) higher than the mean value of morphocluster 1 (2.27 mm, ranged 2.22-2.35 mm) and the overall mean (2.32 mm). hfw mean and range values (0.70mm, o.5-1.0 mm of morphocluster 2 was significantly (P<0.05) higher than the mean and ranges of morphocluster 1 (0.50 mm, ranged 0.48- 0.55 mm) and the overall means (0.58 mm). Conversely, morphocluster 1 mean and range values at ew (0.51 mm, ranging 0.49-0.52 mm) was significantly (P<0.05) higher than the overall means (0.23 mm) and morphocluster 2 means and range values (0.40 mm, 0.30-0.42 mm). As in ew, the mean value and ranges of dbe and al were also significantly (P<0.05) higher than the same parameters in morphocluster 2 and the overall means.

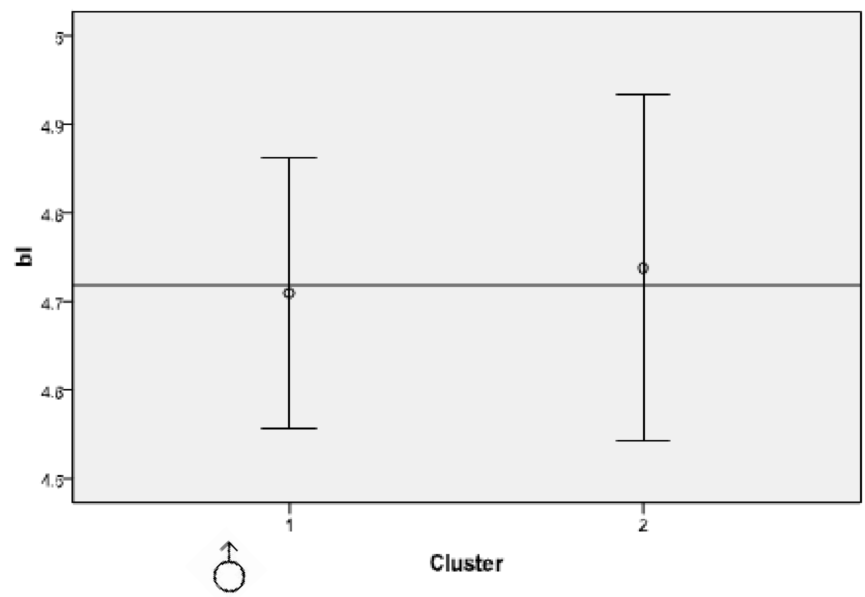
IV. Discussion

In common with several other successful insect pests, C. subinnotatus as a species shows great intraspecific variation in among large morphological traits often accompanied by a tremendous ability to adapt to localize environmental conditions (Ndong et al., 2012).

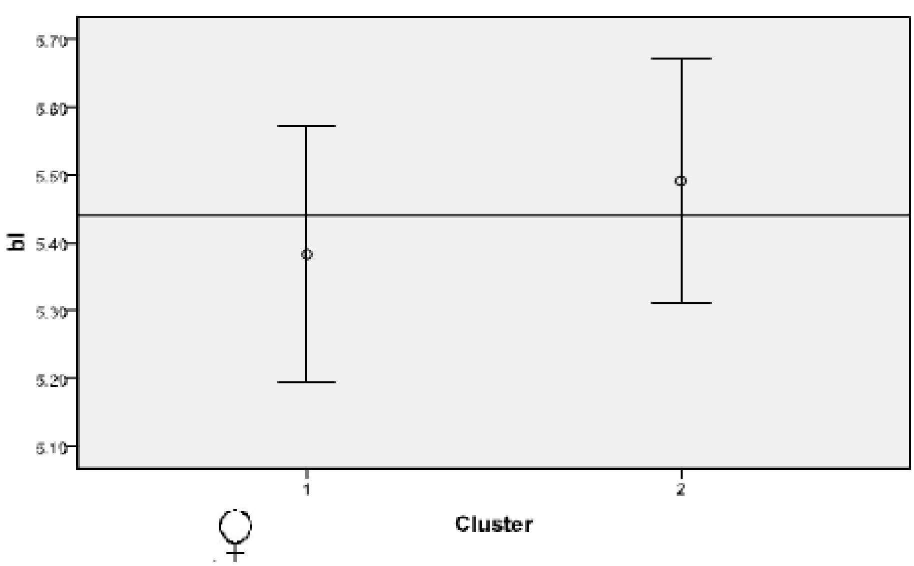
The occurrence of intraspecific variation will have a significant impact on the development and implementation of effective, long term and sustainable control method against C. subinnotatus and, potentially, other bruchids species.

Morphometric studies on the species gave two distinct morphoclusters (1 and 2) and possibly suggesting the existence of two morphs or races of C. subinnotatus in Northwestern Nigeria. Centroids of morphocluster 2 are significantly (P<0.05) higher than morphocluster 1 at body length; body width; length of pronotum; width of pronotum anterior and with of pronotum base while at eye width; distance between eyes and antennal length Morphocluster 1 had higher values. These findings have shown that morphocluster 2 are relatively larger in size than morphocluster 1 and both forms studied were uniformly dark brown to black with elytra relatively longer than wide.. This corroborates the work of Credland and Appleby (2001) which reported the existence of two adult morphs of C. *subinnotatus* termed 'active' and 'normal' forms. They differed in morphology, physiology and behavior and that variation in their characteristics suggests their adaptation to different environments of field and seed stores.

The hind femoral width, eye width and width of pronotum base were both twice the width of coxa, distance between eyes and width pronotum anterior respectively and thus may serve as additional taxonomic tool for identifying C. *subinnotatus*. The explanatory variables revealed hind femur to be bicarinate with inner tooth acutely triangular and slightly longer than the outer tooth concurring with the report of Southgate, (1958).

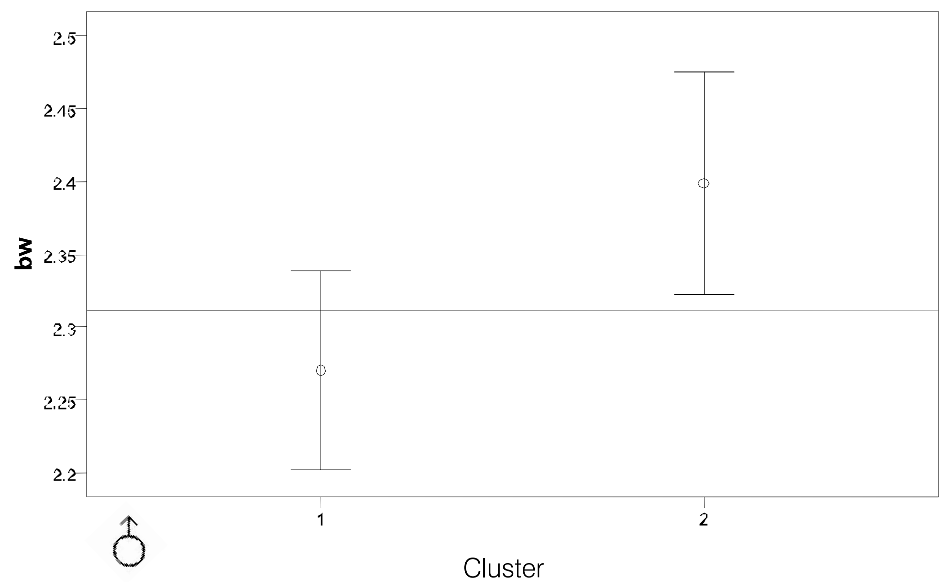


Cluster
Reference Line is the overall Mean =4.72

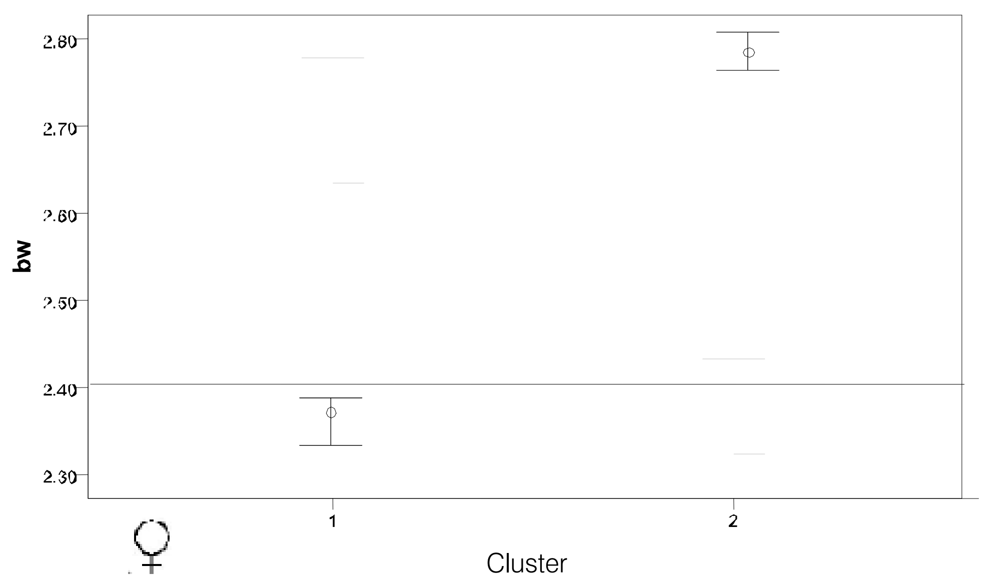


Cluster
Reference Line is the overall Mean =5.44

Figure 2a : Means and Simultaneous 95% Confidence Intervals of body length (bl) in *Callosobruchus subinnotatus* male and female respectively.

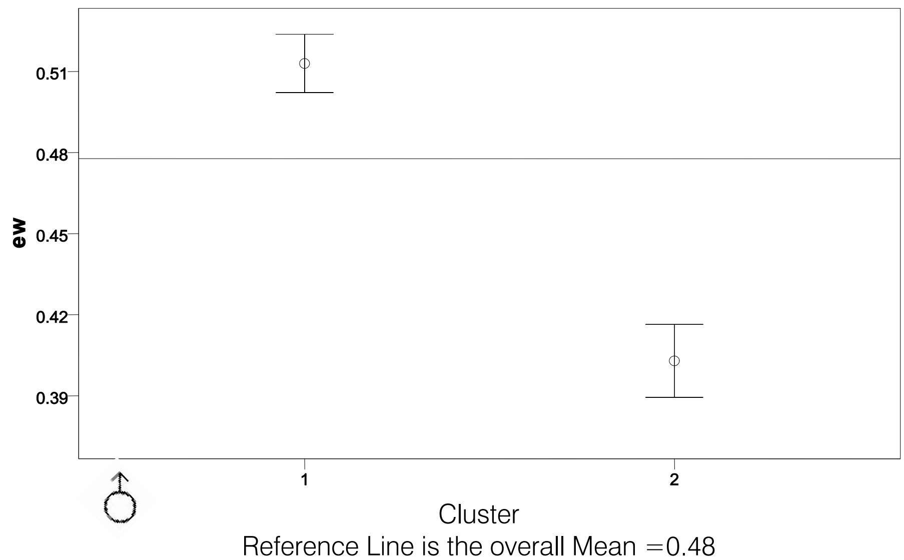


Cluster
Reference Line is the overall Mean =2.32



Cluster
Reference Line is the overall Mean =2.40

Figure 2b : Means and Simultaneous 95% Confidence Intervals of body width (bw) in *Callosobruchus subinnotatus* male and female respectively.



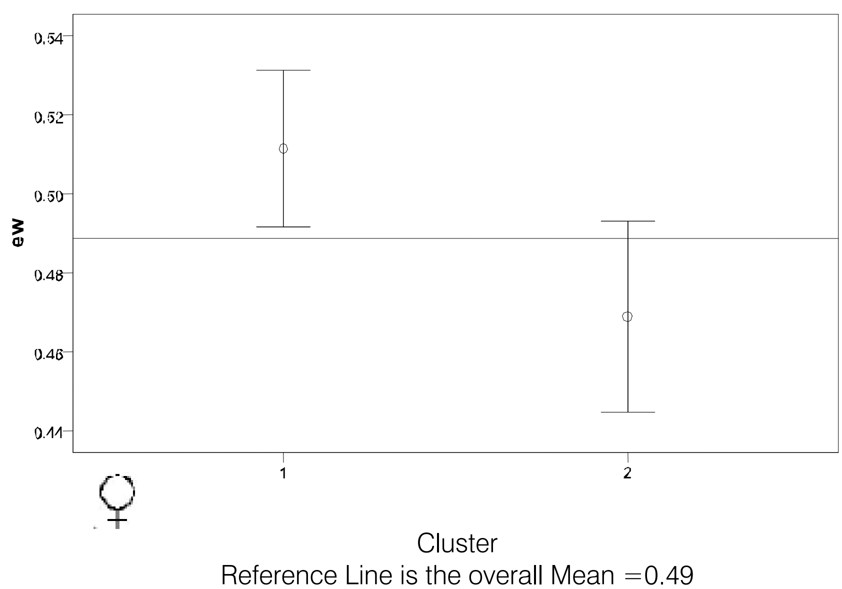
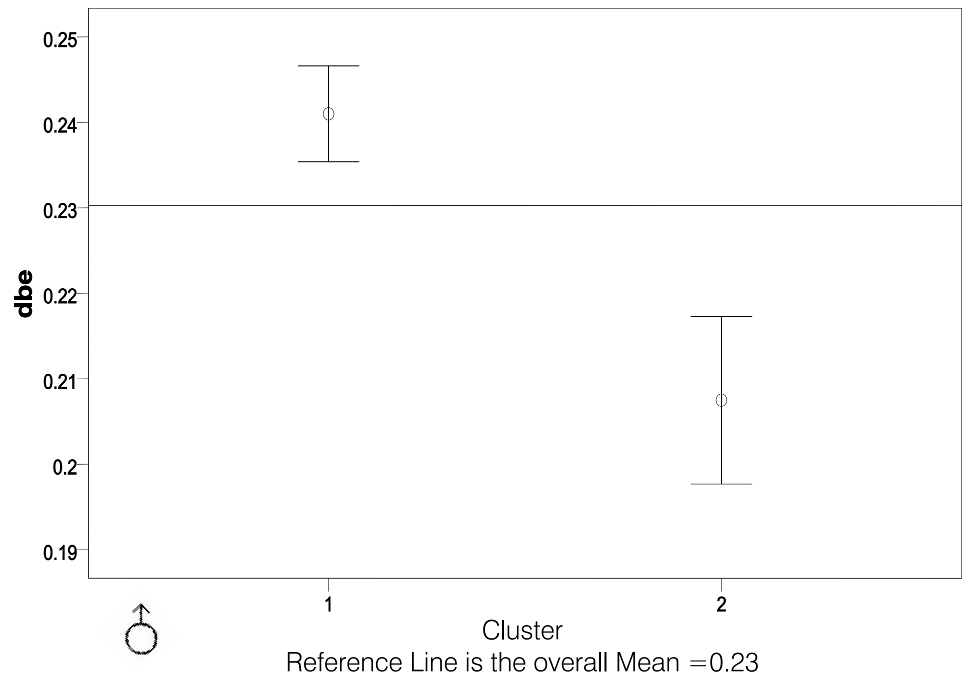


Figure 2c : Means and Simultaneous 95% Confidence Intervals of eye width (ew) in *Callosobruchus subinnotatus* male and female respectively.



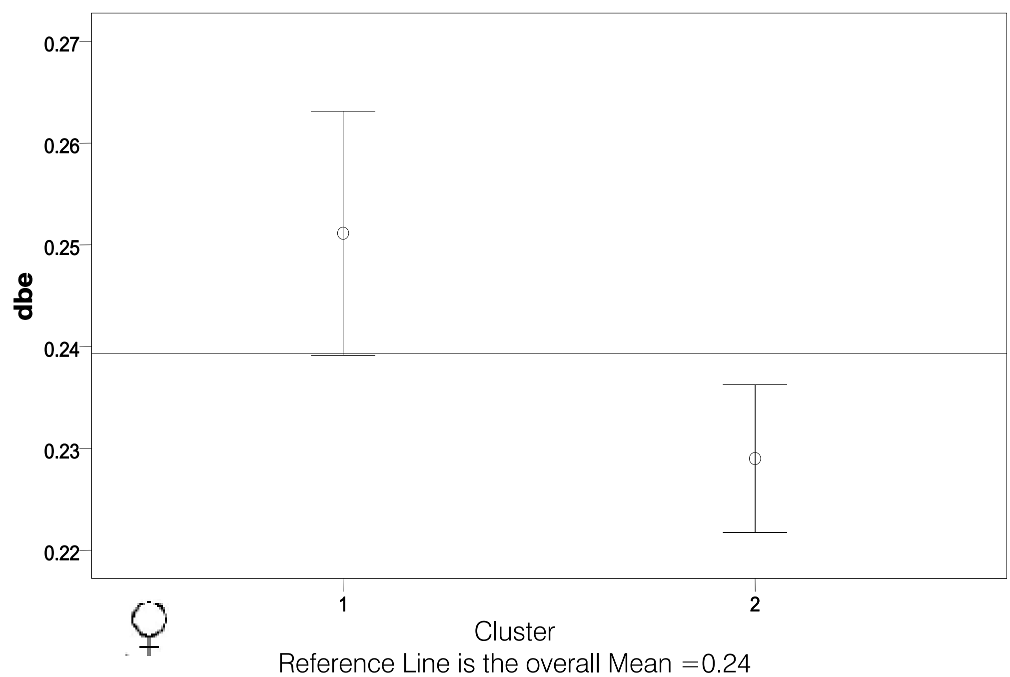


Figure 2d : Means and Simultaneous 95% Confidence Intervals of distance between eyes (dbe) in *Callosobruchus subinnotatus* male and female respectively.

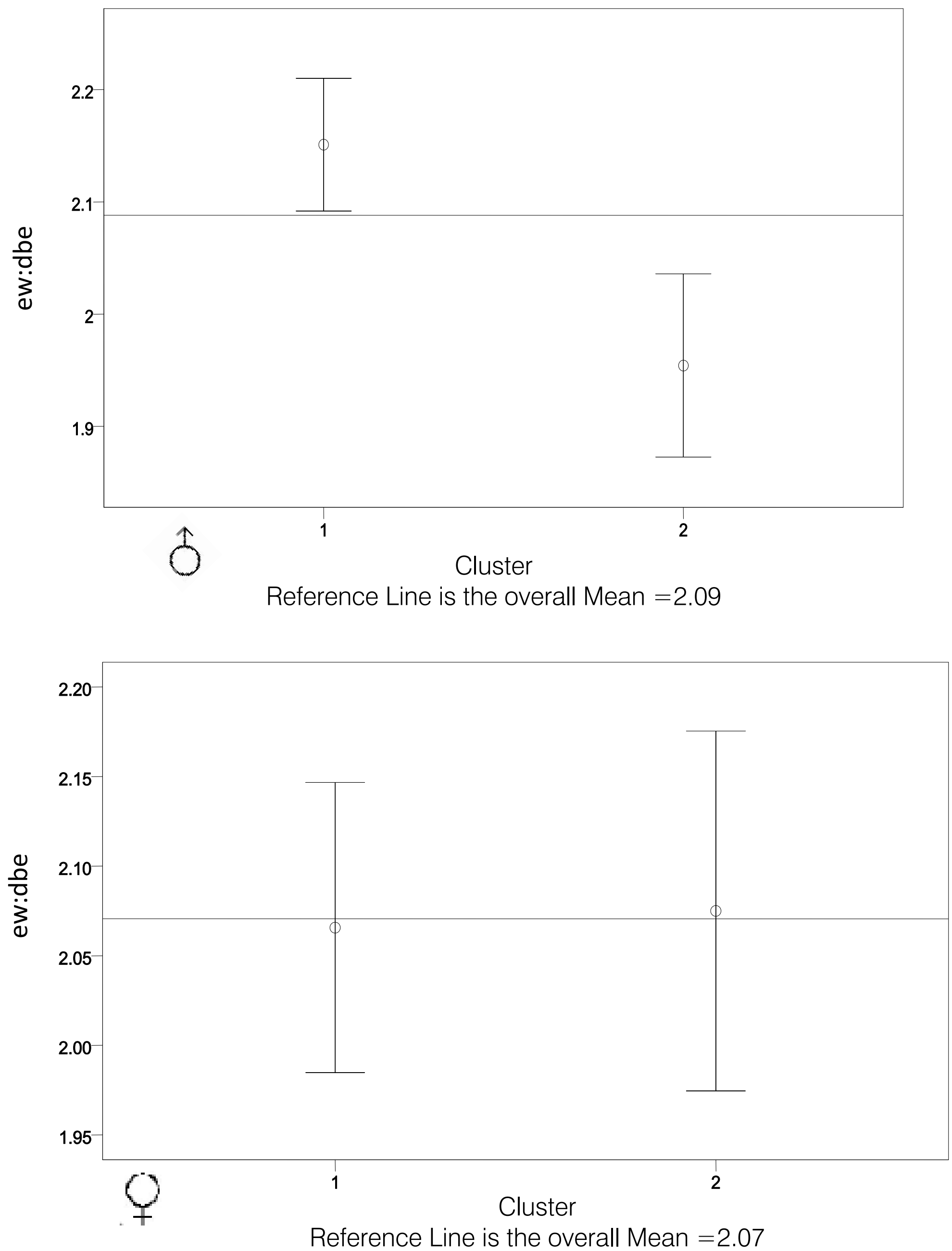
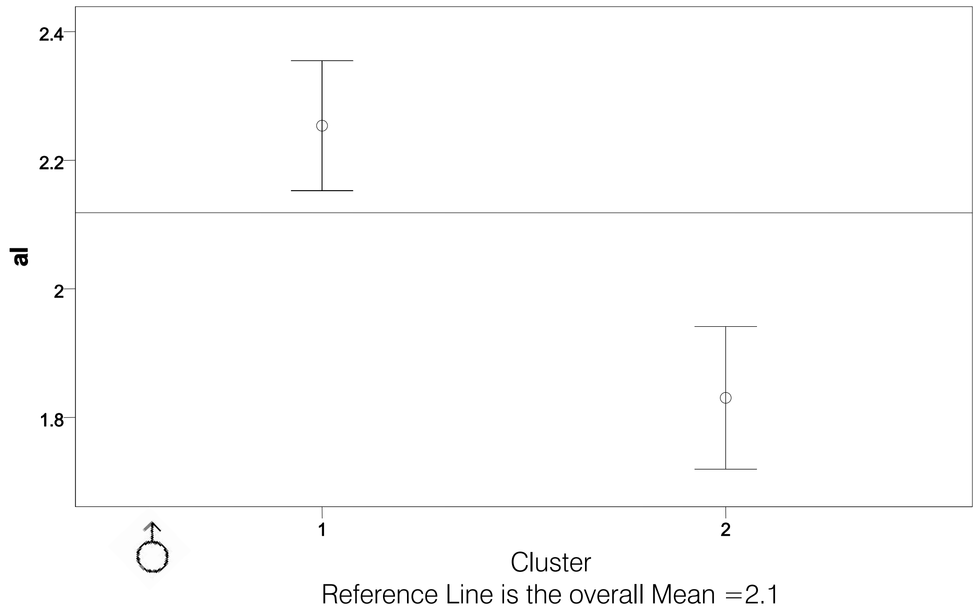


Figure 2e : Means and Simultaneous 95% Confidence Intervals of eye width ratio distance between ey (ew:dbe) *Callosobruchus subinnotatus* male and female respectively.



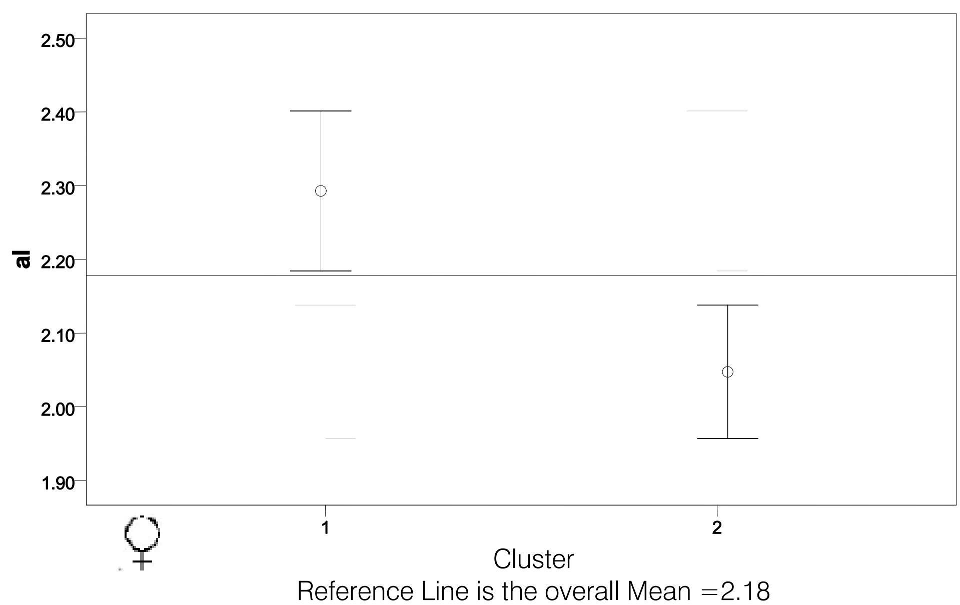


Figure 2f : Means and Simultaneous 95% Confidence Intervals of antennal length (al) in *Callosobruchus subinnotatus* male and female respectively.

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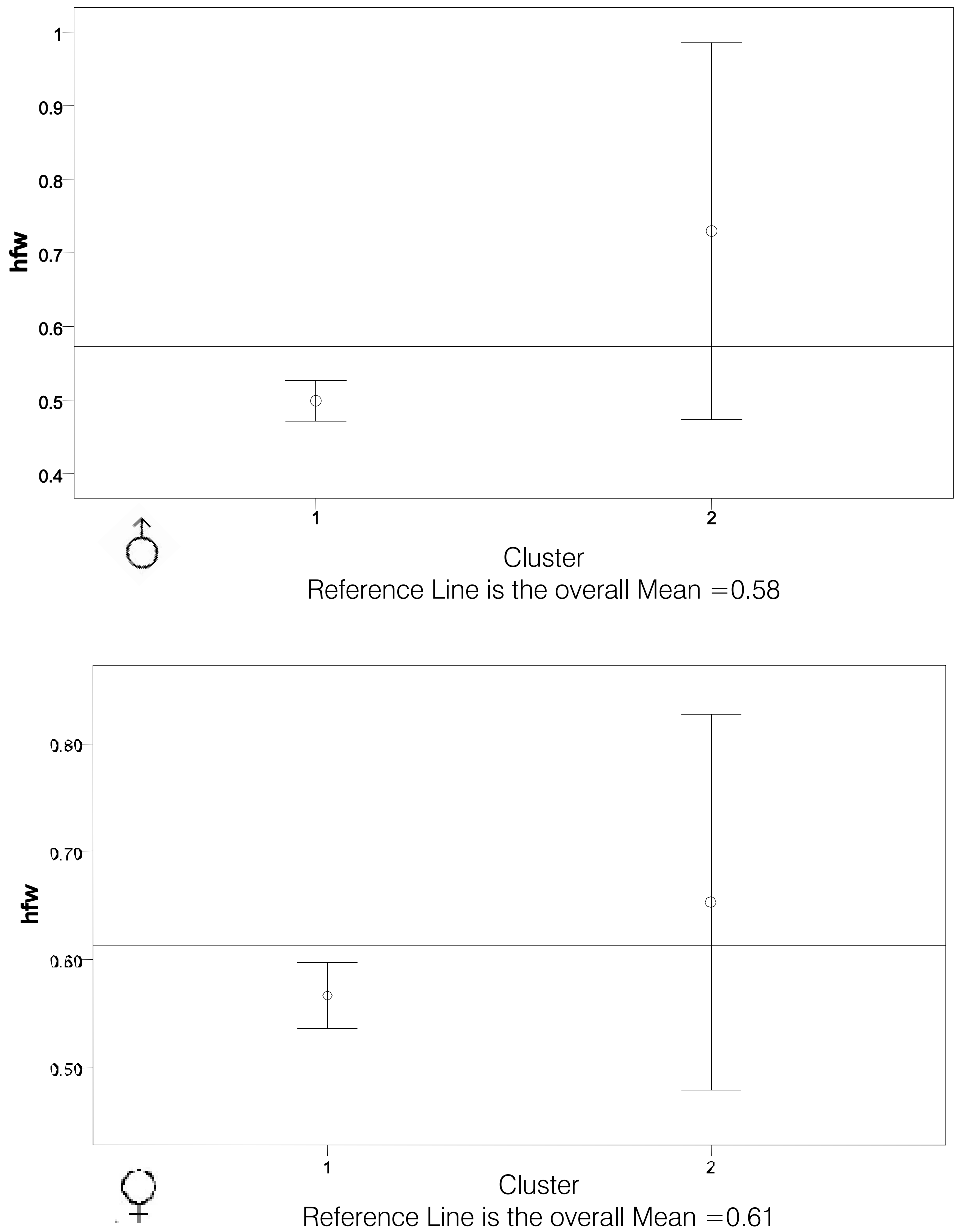
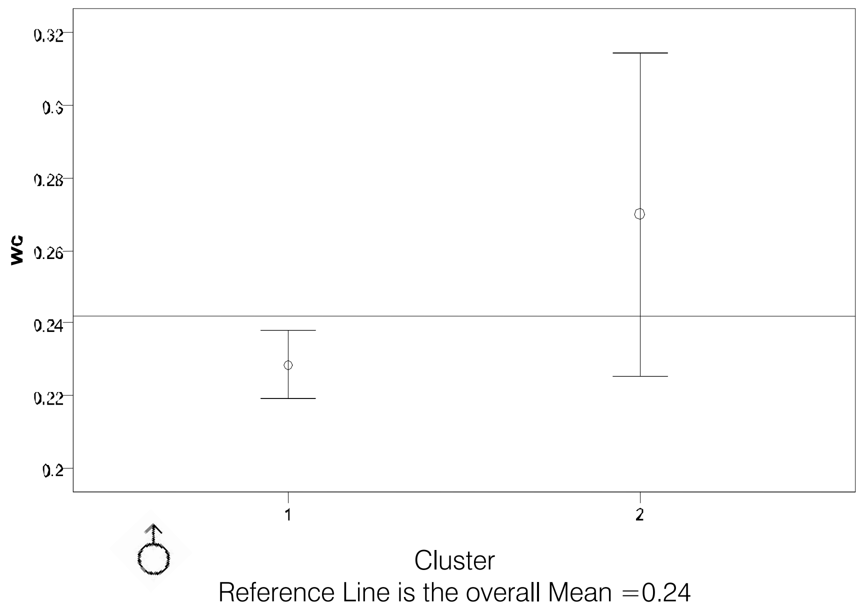


Figure 2g : Means and Simultaneous 95% Confidence Intervals of hind femoral width (hfw) in *Callosobruchus subinnotatus* male and female respectively.



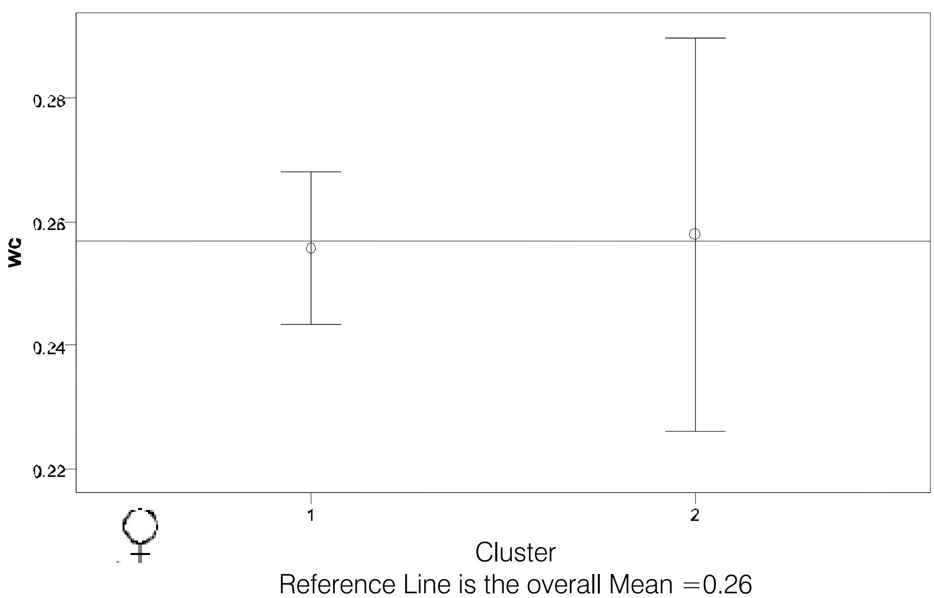


Figure 2h : Means and Simultaneous 95% Confidence Intervals of width of coxa (wc) in *Callosobruchus subinnotatus* male and female respectively.

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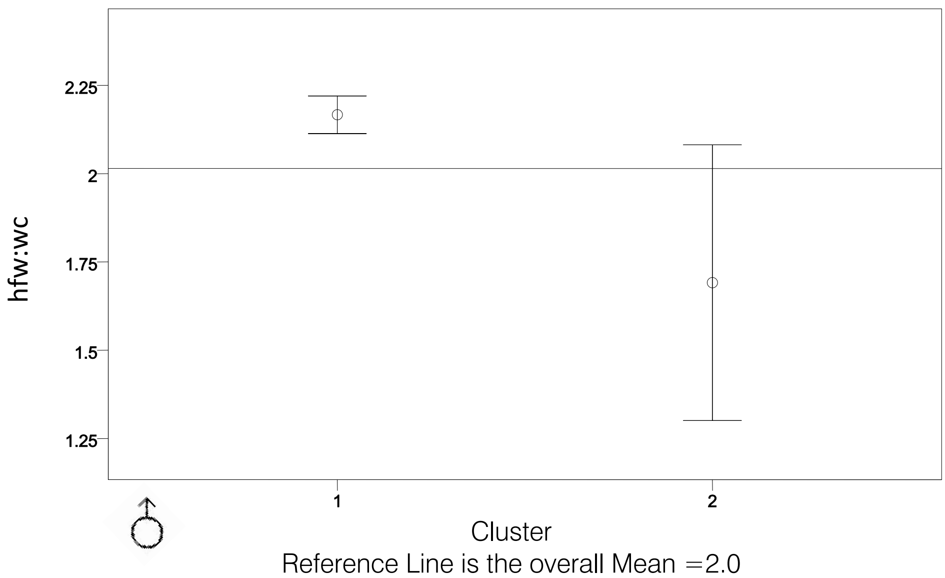


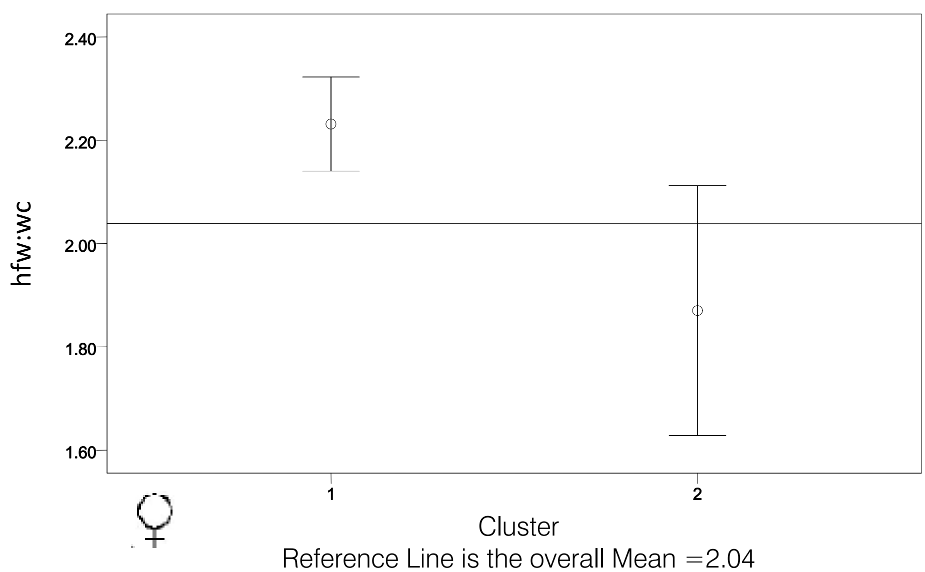


Figure 2i : Means and Simultaneous 95% Confidence Intervals of hind femoral width ratio width of coxa (wc) in *Callosobruchus subinnotatus* male and female respectively.

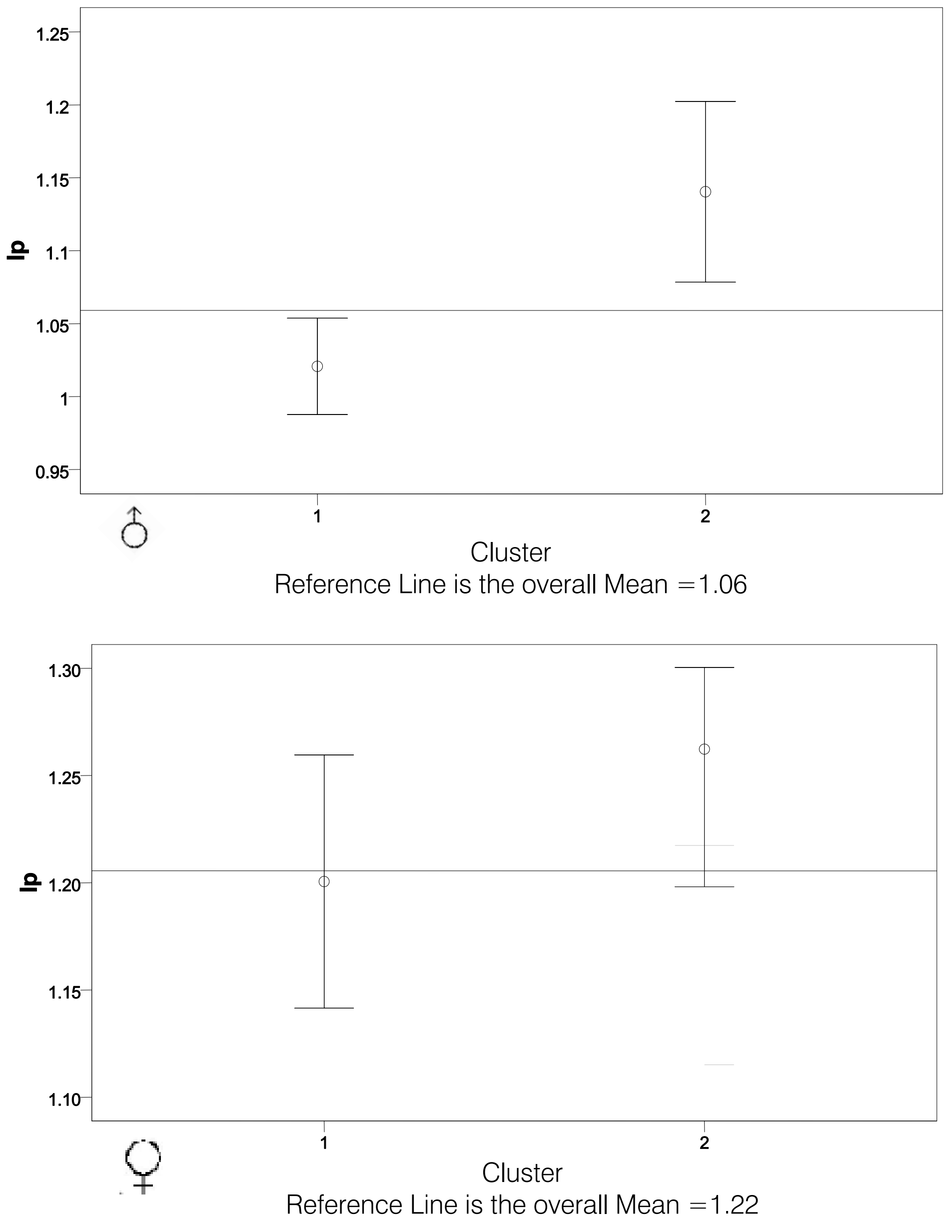


Figure 2j : Means and Simultaneous 95% Confidence Intervals of length of pronotum (lp) in *Callosobruchus subinnotatus* male and female respectively.

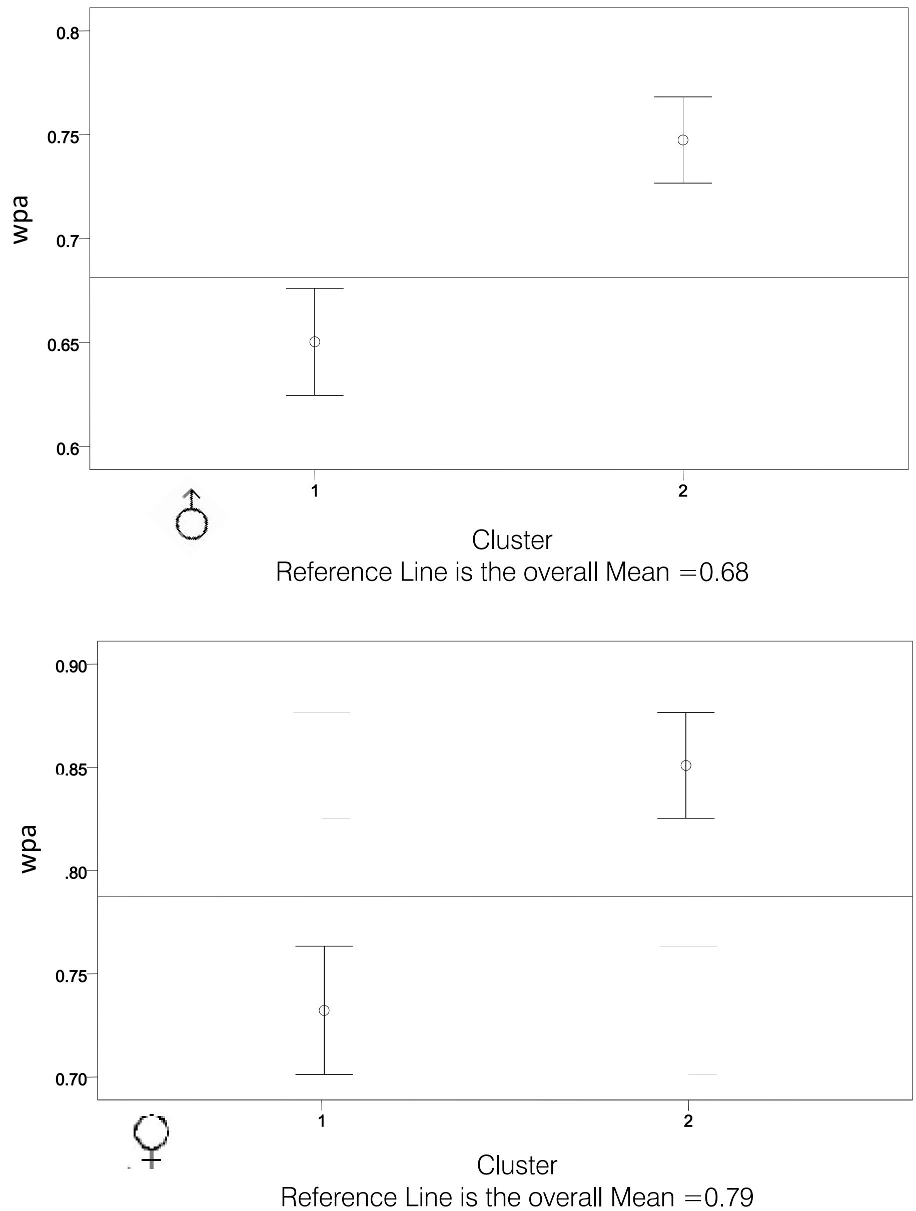


Figure 2k : Means and Simultaneous 95% Confidence Intervals of width of pronotum anterior (wpa) in *Callosobruchus subinntatus* male and female respectively.

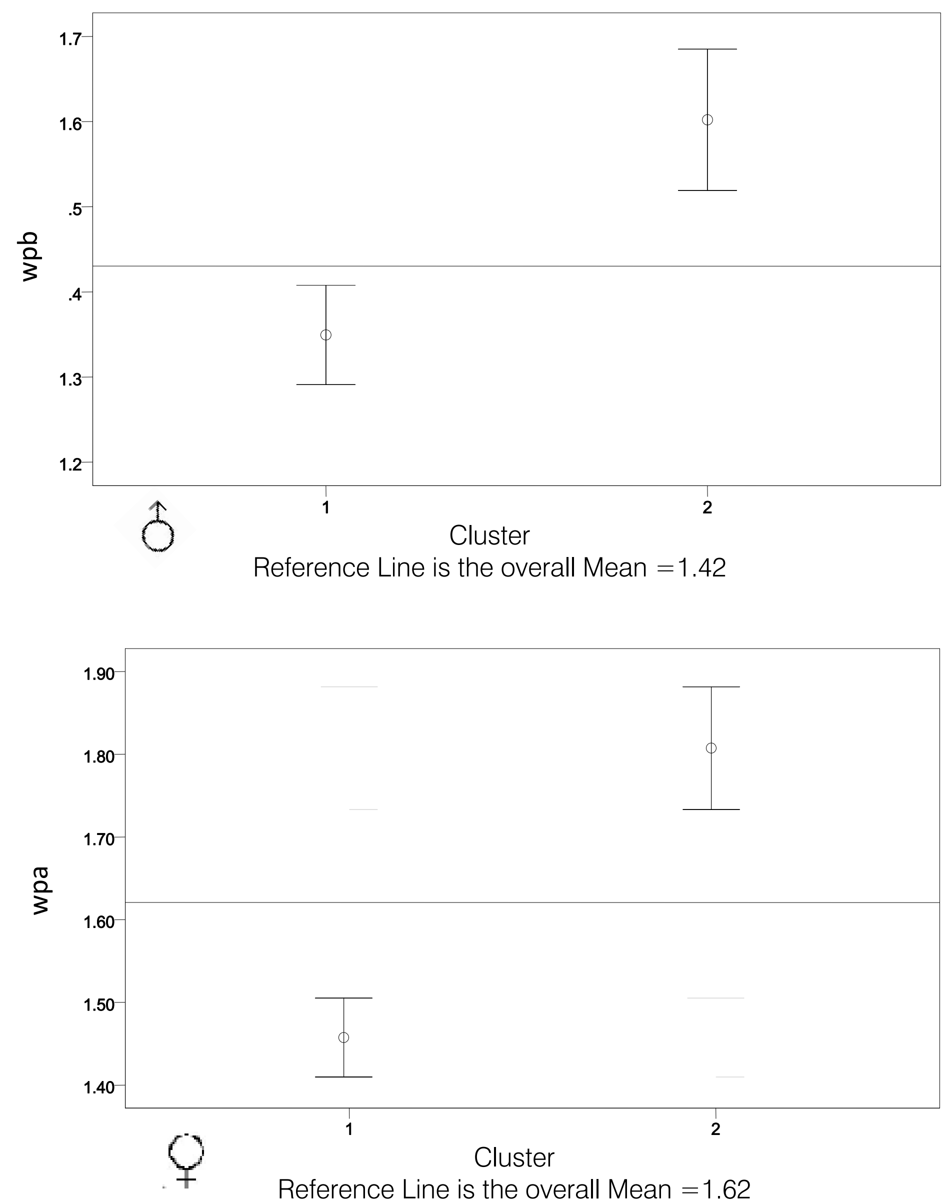
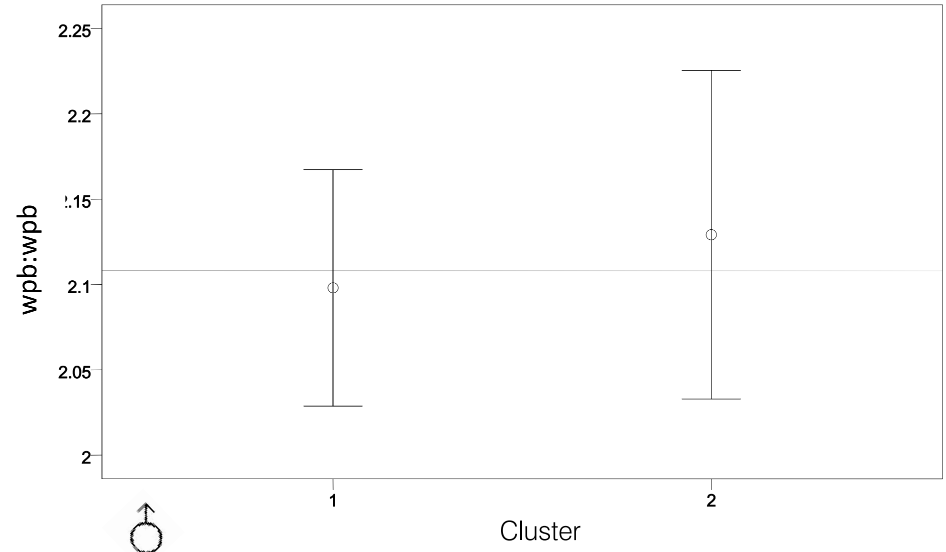


Figure 2l : Means and Simultaneous 95% Confidence Intervals of width of pronotum base (wpb) in *Callosobruchus subinnotatus* male and female respectively.



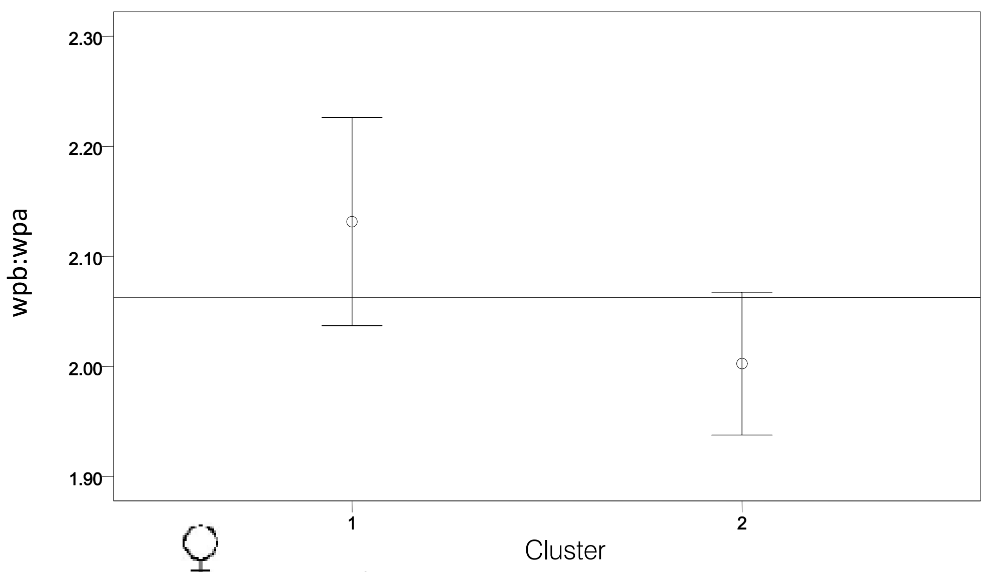


Figure 2m : Means and Simultaneous 95% Confidence Intervals of width of pronotum base ratio width of pronotum anterior (wpb:wpa) in Callosobruchus subinnotatus male and female respectively.

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Evaluation of Rice (*Oryza Sativa* L) Based Cropping Systems in Major Soil Series of Upper Brahmaputra Valley Asom

By Dharam Singh, B.P. Bhaskar, U. Baruah & Dipak Sarkar

Abstract- On farm field experiments were conducted during 2005 to 2008 to evaluate production and land use efficiency of rice (Oryza sativa L.) based cropping systems in four major soil series of upper Brahmaputra valley of Asom. The rice cultivar Basundhara and Satyaranjan were followed by three winter crops viz., potato (Solanum tuberosum), peas (Pisum sativum) and mustard (Brassica nigra) on four major soil series viz., Lahangaon (Aeric Fluvaquents), Bhogdai (Fluvaquventic Endoaquepts), Matikhola (Typic Endoaquepts) and Teok (Typic Fluvaquents) of Jorhat district in split-split plot design under farmers practice (FP) and recommended package of practices (RPP). The pooled data on rice equivalent yield (REY) of rice– potato Lahangaon series (156.6 q ha-1) under RPP was found economically significant followed by Bhogdai (138.4 q ha-1) and Matikhola (111.07 q ha-1) but rice –pea (100.9 q ha-1) in Teok series. The high production efficiency is recorded for rice–pea system with mean of 54.95 kg ha-1day-1 and highest of 66.7 kg ha-1day-1 in Lahangaon series and an increase of land use efficiency from 35 to 70 percent. The agronomic performance of rice based systems under RPP was well over FP at all the soil series, but best results were recorded at Lahangaon series.

Keywords: rice, winter crops, soil series, brahmaputra valley.

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Dharam Singh [α], B.P. Bhaskar [σ], U. Baruah [ρ] & Dipak Sarkar [ω]

Abstract- On farm field experiments were conducted during 2005 to 2008 to evaluate production and land use efficiency of rice (*Oryza sativa* L.) based cropping systems in four major soil series of upper Brahmaputra valley of Asom. The rice cultivar *Basundhara and Satyaranjan* were followed by three winter crops viz., potato (*Solanum tuberosum*), peas *(Pisum sativum)* and mustard (*Brassica nigra*) on four major soil series viz., Lahangaon *(Aeric Fluvaquents), Bhogdai (Fluvaquventic Endoaquepts), Matikhola (Typic Endoaquepts) and Teok (Typic Fluvaquents)* of Jorhat district in split-split plot design under farmers practice (FP) and recommended package of practices (RPP). The pooled data on rice equivalent yield (REY) of rice–potato *Lahangaon* series (156.6 q ha-1) under RPP was found economically significant followed by *Bhogdai* (138.4 q ha-1) and *Matikhola* (111.07 q ha-1) but rice –pea (100.9 q ha-1) in *Teok* series. The high production efficiency is recorded for rice –pea system with mean of 54.95 kg ha-1day-1 and highest of 66.7 kg ha-1day-1 in *Lahangaon* series and an increase of land use efficiency from 35 to 70 percent. The agronomic performance of rice based systems under RPP was well over FP at all the soil series, but best results were recorded at *Lahangaon* series.

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I. Introduction

A cropping system signifies the sequence of crops grown over a specific piece of cultivated land and to increase the benefits from the available physical resources. Therefore, the basic approach in an efficient cropping system is to increase production and economic returns (Yadav *et al*. 1998). *A* flexible cropping system helps in capturing economic opportunities and environmental realities (Gangwar *et al*. 2004) and in ensuring balanced farm growth at regional level (Reddy and Suresh 2009). Hence, selection of component crops needs to be suitably planned for efficient utilization of resource base and to increase overall productivity (Anderson 2005). Inclusion of crops like oilseeds, pulses, vegetables and fodder crops will improve the economic condition of small and marginal farmers owing to higher price and/or higher volume of their main and by-products (Sharma *et al* . 2007). Economics of the rice-based cropping systems showed that the highest profit (Rs 85,012/-) was found in case of rice – lentil followed by rice – wheat - mungbean which gave Rs 82,671/- per hectare. The lowest profit (Rs 38,065/-) was obtained in case of rice-wheat-sesbania cropping pattern (Ali *et al*. 2012). Among other cereals, wheat and maize was gaining some popularity among the farmers in Assam. Oilseed was next to rice in coverage, and then the fibers and pulses. Pulses, oilseeds and jute jointly accounted for 16% of area (Bhowmick *et al*. 2005). The agro-economic studies in the region lack the link of soil informatics and their relevance in exploring the suitability for expansion of area under pulses and oil seeds. The reconnaissance soil information was used to work out possible crop combinations suitable for this region (Vadivelu et al. 2005 and Bhaskar *et. al*.2010). Rice (Kharif) potato (Rabi) sequence recorded highest gross return of Rs.17 ,644 ha^{-1} and it was found to be superior to all other sequences whereas lowest gross return of Rs.6261 ha-l was reported for jute (S) - niger (R) - cowpea (R) sequence (Maibangsa *et al*. 2000). Based on field observations and interactions with local farmers, economically viable rice based systems with potato, peas and mustard were carried out and worked out the productivity potential, resource use efficiency and land use efficiency under four major soil series of upper Brahmaputra valley.

II. Materials and Methods

On farm field experiments were undertaken on four major soil series in Jorhat district of Assam viz. i. *Lahangaon* Series (26° 37’21” N and 94° 20’43” E, Coarse loamy, Aeric Fluvaquents), ii. *Bhogdai* Series (26°40’45” N and 94° 12’34”E, Fine loamy, Fluvaquentic Endoaquepts), iii. *Matikhola* Series (26° 49’06” N and 94° 22’56” E, Fine loamy, Typic Endoaquepts) and iv. *Teok* series (26° 49’00” N and 94° 14’00” E, Coarse silty Typic Fluvaquents).The climate is humid to sub-humid and average rainfall 2076 mm. Experimental area is the part of Brahmaputra river basin with elevation of 80 to

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120 m above mean sea level. Brief description of soil series is given below:-

Moderately well drained *Lahangaon* series on very gently sloping alluvial plains have stratic textural contrast with water table below 3.5 m and have yellowish brown mottles below 0.75 m to 1m.This soil has coarse loamy particle size and moderately acid with 98% base saturation and deficiency of phosphorus and moderate amounts of nitrogen and potassium (Table 1). Moderately well drained *Bhogdai* series have fine loamy texture (clay content >33.84%) and base saturation less than 55%.This soil is poorly drained during rainy season but improves during winter as ground water recedes below 3 m. Poorly drained, fine loamy *Matikhola* series is frequently flooded during rainy season with strong acid but coarse silty Teok series have shallow water table (< 1 m) and deficient in potassium and phosphorus.

The field experiments in Spilt-Split Plot Design with 5 replications (Cochran and Cox 1957) were conducted during November 2005 to December 2007. Tow rice cultivar, Basundhara and Satyaranjan under two management levels i.e., farmers practices (FP) and Recommended Package of Practices (RPP). The cropping sequences consisting of (i) Rice-fallow under FP, while (ii) Rice-Potato (iii) Rice-Pea and (iv) Rice Mustard under RPP. Plot size is 50 m^2 each. These crops were raised under rainfed conditions. Potato, pea and mustard were sown in 2^{nd} week of December. Rice seedling was prepared in nursery with 60 kg seeds for transplanting of one hectare area as per standard recommendation of DOA and AAU. Seed rate was 25 q ha^{-1} for potato and 40 kg ha^{-1} for pea and 15 kg ha^{-1} for mustard respectively.

Recommended doses of NPK (kg ha^{-1}) were 60:100:100 for potato, 20:40:0 for pea and 60:40:6 for mustard. Fertilizers were supplied through urea, single super phosphate (SSP) and muriate of potash (MOP) respectively. Half the quantity of recommended N and entire amount of P_2O_5 and K_2O was applied as basal dose. Remaining half dose of N has been applied in two split doses i.e., at 45 days and 60 days after sowing as top dressing. Similar practices were also followed for rice with the application of 40:20:20 N, P_2O_5 and K_2O kg ha^{-1}. Soil physical and chemical properties of the experimental fields were determined for samples taken during planting in the Soil and Plant Analysis Laboratory of Regional Centre, Jorhat.

The land use efficiency was worked out by dividing total duration of crops in individual crop sequence by 365 days (Chuang 1973). Production efficiency values were obtained by dividing total production in sequence by total duration of a cropping sequence (Tomar and Tiwari 1990).The rice equivalent yield, was calculated as :- REY $=\Sigma(yi.ei)$

Where REY = Rice equivalent yield (Q/ha/yr), ei = the rice equivalent factor and calculated as PC/PR, where PC is the price of a unit weight of rabi crop and PR is the price of a unit weight of rice and y i= economic yield of 1 to n number of crops (Angeneyulu *et al*.1982).

Minimum support price or prevailing market rate of product (rice @ Rs.650 q^{-1}, potato @ Rs.300 q^{-1}, mustard @ Rs 2400 q-^{1}, green pea pods @ Rs.900 $^{q-1}$, rice straw, potato haulm, mustard Stover and pea fodder @ Rs.20 q^{-1}) were taken.

III. Result and Discussion

a) Kharif rice yield

The rice gave maximum yield of 60.6 q ha^{-1} in *Lahangaon* series under RPP as compared to *Bhogdai* series (54.2 q ha^{-1}), *Matikhola* (53.37) and *Teok* (54.6 q ha^{-1}).The yields are almost double under RPP over FP with similar yield trends with respect to soil types. These findings are in agreement with results of Gogoi *et at*. 2010. The slight variations in rice yields over soil types under farmers practice vary from 28.45 q ha^{-1} in *Lahangaon* series to 26.25 q ha^{-1} in *Teok* series (Table 2).

b) Rabi crop yield

The mean tuber yield of *rabi* potato *rabi)* is 141.9 q ha^{-1} where as 55.47 q ha^{-1} for *kharif* rice 46.4 q ha^{-1} for *rabi* pea and 5.77 q ha^{-1} for *rabi* mustard. The yield of potato, pea and mustard under farmers practice is 53.41, 21.20, and 2.75 q ha^{-1}, respectively but highest relative yield of 165.68 percent over control is recorded in case of potato but of 118.86 per cent for pea and 109.8 percent for mustard. It was reported that the agronomic performance of rice-potato system is good with incorporation green manure @10t ha^{-1} or legume crop in Nepal (Khatri *et al*. 2004). The mustard yields are high in coarse loamy *Lahangaon* series which is in agreement with the findings of Shekhawat *et al*. (2012) who reported that mustard is moderately tolerant to soil acidity, preferring a pH from 5.5 to 6.8, thrives in areas with hot days and cool night and requires well-drained sandy loam soil with water requirement of 240–400 mm. The variations in yield of *rab*i crops may be due to genetic make as well as environmental factors in which crop species grown (Sahu 1972). The upland moderately well drained *Lahangaon* and *Bhogdai* series are adjudged as suitable for potato and peas crops during *rabi* as drainage improves along with porosity and structure. The mustard is grown extensively in the region as irrigation potential is meager and requires low water.

c) Rice based cropping sequences

i. *REY of rabi crops*

The pooled data indicate that under farmers practice , peas recorded REY of 35.3 in *Lahangaon* soil and 19.9 in *teok* soil but under RPP, REY in same soil types for peas varied from 80.3 to 46.3 (Table 2). Potato gave highest REY in *Lahangaon* soil under RPP (96) but decreased to 84.2 in *Bhogdai*, 57.7 in *Matikola* and 24.1 in *Teok* series with a mean of 65.50 which is slightly higher than peas (64.3) q ha-1. This is probably due to higher production potential of potato and peas coupled with the high price in the sequence that increased the rice-equivalent yield values (Banik and Bagchi 1996 and Banik *et al*. 1999).

ii. *REY of cropping systems*

REY of pooled data shows distinct variations with respect to soil types with overall productivity mean of 86.32 and an increase in yield over Farmers practice of 290.96 per cent. The order of increasing in REY for cropping systems under RPP is as follows. *Lohangaon, Bhogdai, Matikhola and Teok* (Table 2) and highest for rice – potato (mean of 121.19) q ha-1. The per cent increase over farmers practice is highest for rice -potato (346.87%) which is more than 342 per cent for peas and 184.92 for mustard systems. The REY data shows that *Lohangaon* series is suitable for rabi potato, peas and mustard as compared to Matikhola and Teok series. These findings are in agreement with observations of Vadivelu et al. (2005) with coarse silts over sand, slightly to moderately alkaline, low amount of exchangeable potassium, available phosphorus and zinc.

d) System productivity

Highest productivity 156.6 was recorded under rice -potato cropping system at Lahangoan series with RPP followed by rice-pea 140.9 and rice- mustard 95.6 q ha^{-1} as compared to FP. Similar trends were also observed in Bhogdai and Matikhola series but at Teok rice- pea (100.9) performed better then rice-potato (78.7) and rice - mustard 57.92 q ha^{-1}. Overall productivity mean under RPP was 106.06 q ha^{-1} and an increase in system productivity yield 291.41 percent over to FP.

e) Production efficiency

The low production efficiency under farmers practice is varied from 22.23 in *Lohangaon* series to 20.66 kg ha^{-1} day^{-1} in *Teok* series for rice fallows with an overall mean of 20.23 kg ha-1 day-1. The high production efficiency is recorded for rice – pea system with mean of 54.95 and highest of 66.7 kg ha-1 day-1 in *Lahangaon* series (Table 2). The production efficiency of rice - potato under RPP is high in *Bhogdai* series (64 kg ha^{-1} day^{-1}). The production efficiency of rice - mustard system is even though low as compared to rice-pea and rice –potato system but shows an order of decrease from *Lohangaon* (45.1) to 25.9 kg ha^{-1} day^{-1} in Teok series. Higher production efficiency was obtained with integrated use of chemical fertilizers because of prolonged supply of nitrogen as a result of minerailization (Reddy *et al*. 2004)

f) Land Use Efficiency

The land use efficiency for rice fallow is 35 per cent but varied from 32 in *Lahangaon* /*Bhogdai* series to 37 per cent in *Matikhola*/*Teok* series. The 70 per cent land use efficiency is recorded for rice-potato, 68 per cent for rice -peas and 65 per cent for rice – mustard under RPP. The improved land use efficiency with the inclusion of potato, peas and mustard in rice fallows is from 35 to 68 per cent. It was reported that land use efficiency increased to 80 per cent under rice –potato-green gram sequence in Varanasi due to intensification and employment generation (Bohra et al. 2007 and Tripathi and Alok Kumar, 2010).

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Table 1 : Soil-site characteristics

Soil-site characteristics	Coarse loamy Aeric Fluvaquents *Lahangaon* series	Fine loamy Fluvaquentic Endoaquepts *Bhogdoi* series	Fine loamy Typic Endoaquepts *Matikhola* series	Coarse silty Typic Fluvaquents *Teok* series
Slope (%)	Very gently (1-3)	Nearly level (0-1)	Nearly level (0-1)	Nearly level (0-1)
Elevation (m)	120	100	90	80
Physiography	Lower piedmont	Gently sloping upland	Very gently sloping plain	Lower flood plain
Sand (%)	54.0	21.03	48.22	42.70
Silt (%)	29.5	45.13	31.28	34.90
Clay (%)	16.5	33.84	20.50	22.40
pH (H_2O 1: 2.5)	5.5	5.2	5.1	5.0
OC (%)	1.06	0.80	1.26	1.26
CEC	6.0	10.7	12.82	5.28
Base saturation (%)	98.0	55.0	98.00	18.00
Drainage	Poor in rainy season and well drain winter	Poor in rainy season and well drain winter	Poor in rainy season and moderately well in winter	Poor in rainy season and moderately well in winter
Water Table (m)	3.5	3.0	(flooding) 1.5	(flooding) 1.00
Soil fertility status kg ha^{-1}				
N	264.50	352.80	352.80	423.36
P_2O_5	3.23	3.27	3.67	3.09
K_2O	145.86	165.43	91.37	90.60

Table 2 : Crops yield, rice-equivalent yield, production efficiency, land-use efficiency of different rice base cropping sequences in major soils of Asom (pooled)

cropping system	Coarse- Loamy (Aeric Fluvaquents) *Lahangaon* Series	Fine-Loamy (Fluvaquentic Endoaquepts) *Bhogdai* Series	Fine-Loamy (Typic Endoaquepts) *Matikhola* Series	Coarse-Silty (Typic Fluvaquents) *Teok* series	Mean	Increase in yield over control (%)
Crop Yield (q ha^{-1})						
Rice –fallow	28.45	27.20	26.40	26.25	27.12	-
Rice (RPP) *Kharif*	60.60	54.20	53.37	54.60	55.47	104.54
Increase in yield (%)	113.01	99.27	102.16	108.0	104.54	-
Rabi						
Potato (control)	58.07	62.10	48.00	45.45	53.41	-
Potato (RPP)	208.00	182.50	125.00	52.10	141.90	165.68
Mustard (control)	25.50	24.30	20.70	14.30	21.20	-
Pea (RPP)	58.00	55.30	38.70	33.40	46.40	118.86
Pea (control)	4.10	4.10	2.50	0.30	2.75	-
Mustard (RPP)	9.48	8.10	4.60	0.90	5.77	109.80
Rice equivalent yield of *rabi* crops (q ha^{-1})						
Potato (control)	26.80	28.70	22.20	21.00	24.65	-
Potato (RPP)	96.00	84.20	57.70	24.10	65.50	165.72
Pea (control)	35.30	33.70	28.70	19.90	29.35	-
Pea (RPP)	80.30	76.60	53.60	46.30	64.20	118.71
Mustard (control)	15.20	15.00	9.20	1.11	10.16	-
Mustard (RPP)	35.00	29.90	17.00	3.32	21.31	109.74
Rice equivalent yield of cropping systems (q ha^{-1})						
Rice-Fallow (FP)	28.45	27.20	26.40	26.25	27.12	-
Rice –Potato (RPP)	156.60	138.40	111.07	78.70	121.19	346.86
Rice- Pea (RPP)	140.90	130.80	107.00	100.90	120.00	342.47
Rice–Mustard (RPP)	95.60	84.10	70.37	57.92	77.00	184.91
CD (p=0.05)	22.17	9.97	13.58	6.61	*106.00	*291.41
Production efficiency kg ha^{-1} day^{-1}						
Rice –fallow	22.23	20.25	21.49	20.66	20.23	-
Rice –Potato (RPP)	65.10	64.00	44.40	33.10	51.65	255.31
Rice- Pea (RPP)	66.70	59.10	48.00	46.00	54.95	271.63
Rice–Mustard (RPP)	45.10	39.00	33.40	25.90	35.85	177.21
Land use efficiency (%)						
Rice –fallow	32.30	32.30	37.80	37.80	35.05	-
Rice –Potato (RPP)	70.00	70.00	70.70	70.70	70.35	200.71
Rice- Pea (RPP)	68.50	68.50	69.30	69.30	68.90	196.58
Rice–Mustard (RPP)	64.40	64.40	65.20	65.20	64.80	184.88

**Mean of RPP*

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Modeling Maize Production towards Site Specific Fertilizer Recommendation in Ghana

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MODELINGMAIZEPRODUCTIONTOWARDSSITESPECIFICFERTILIZERRECOMMENDATIONINGHANA

Strictly as per the compliance and regulations of :

Modeling Maize Production towards Site Specific Fertilizer Recommendation in Ghana

Williams Kwame Atakora.[α], Mathias Fosu.[σ] & Francis Marthey [ρ]

Abstract- The use of crop growth simulation models such as those incorporated into Decision Support System for Agro technology Transfer (DSSAT) are useful tools for assessing the impacts of crop productivity under various management systems. The maize growth model of DSSAT is CERES-Maize. To use it to predict fertilizer recommendation for maize (*Zea mays* L.) under Guinea savanna agro ecological conditions, data on maize growth, yield and development as well as data on soil and weather were collected from field experiment conducted during the 2010 growing season at Kpalesawgu in Ghana. The model was calibrated using various crop growth and development data observed at the field experiment at Kpalesawgu. Maize variety obatanpa was used in the experiment. The cultivar coefficient was calibrated with data collected from the field experiment. All measured data on phenology, grain yield and biomass from the field experiment were used for model validation and simulations.

Validation results showed good agreement between predicted and measured yields with a NRMSE value of 0.181. Highest observed mean harvest maturity yield of 3831and 3795 kg/ha were obtained from plots which received 120-90-60 and 120-60-60 kg/ha N-P_2O_5-K_2O respectively. However, the model under predicted weight per unit grain. The mean difference between observed and simulated by-product produced at maturity and top weight at maturity was significant ($P \leq 0.001$).In general, maize yield simulation by DSSAT under Guinea savanna agro-ecological conditions was good. Average predicted harvest maturity yields were very close to measured values with MD of 336.0, RMSE of 498.77, NRSME of 0.181 and simulated and observed mean yields of 3096 and 2750 kg/ha for the entire treatments respectively. The mean difference between predicted and observed was not significant. The highest harvest maturity yield predicted and observed was achieved with 120-90-60 kg/ha N-P_2O_5-K_2O. The predicted and observed average mean yield were 3831 and 3999 kg/ha, respectively. Based on the simulation results from this study the DSSAT model appeared to be suitable for the Guinea savanna agro-ecological conditions in Ghana.

Sensitivity analysis results showed that the DSSAT model is highly sensitive to changes in weather variables such as daily maximum and minimum temperatures as well as solar radiation. However, the model was found to be least sensitive to rainfall. Similarly, the model was found to be sensitive to soil and genetic parameter of the cultivar.

I. Introduction

Maize is the most important cereal crop produced in Ghana and it is also the most widely consumed staple food in Ghana with increasing production since 1965 (FAO, 2008., Morris et al 1999). In Ghana, maize is produced predominantly by smallholder resource poor farmers under rain-fed conditions (SARI, 1996). Low soil fertility and low application of external inputs are the two major reasons that account for low productivity in maize. The soils of the major maize growing areas in Ghana are low in organic carbon (<1.5 %), total nitrogen (< 0.2 %), exchangeable potassium (<100 mg/kg) and available phosphorus (< 10 mg/kg) (Adu, 1995, Benneh et al 1990).

From 1969 to 1972, UNDP/FAO carried out series of fertilizer trials with Ministry of Food and Agriculture (MoFA) under UNDP/FAO Ghana Project "Increased Farm Production through fertilizer use." Fertilizer recommendations were made for maize and other crops.

Soil conditions have changed over the years and the old recommendations are not the most efficient today hence the need to update fertilizer recommendations for maize (and other crops) in Ghana. It is therefore necessary to quickly update fertilizer recommendation for maize using modern tools which will not only evaluate the profitability of crop productions but also the quality of the environment within which crop production is carried out, and combine crop, soil and genetic components of crop production. Decision Support System for Agro-technology transfer (DSSAT) model is one of such tools.

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Table 1 : Soil chemical attribute used for running the DSSAT model

	Mean	Min.	Max.	Std. deviatin	Std. Error of Mean	Variance	CV
pH (1:2.5 Water)	5.053	4.700	5.300	0.203	0.052	0.041	4.019
mg (cmol./kg soil)	1.435	0.400	2.540	0.565	0.146	0.319	39.352
K (cmol./kg soil)	0.197	0.110	0.270	0.047	0.012	0.002	23.978
ECEC (cmol./kg soil)	4.027	2.510	5.310	0.747	0.193	0.588	18.545
Organic Carbon (%)	0.237	0.060	0.480	0.158	0.041	0.025	66.611
Calcium (cmol./kg soil)	1.613	0.670	2.540	0.464	0.120	0.216	28.788
Total Nitrogen (%)	0.028	0.110	0.060	0.015	0.004	0.001	52.956

Table 2 : Soil physical attribute used for running the DSSAT model

	Mean	Min.	Max.	Std. deviation	Std. Error of Mean	Variance	CV
Bulk Density (g/cm^3)	1.613	0.670	2.540	0.464	0.120	0.216	28.788
Clay (%)	21.31	17.000	36.100	4.510	1.170	20.360	21.180
DULL (mm/mm^3)	0.167	0.124	0.294	0.046	0.012	0.002	27.516
Silt (%)	14.45	0.020	32.100	6.260	1.620	39.200	43.340
SLL (mm/mm^3)	0.106	0.078	0.180	0.028	0.007	0.001	26.722
Stones (%)	26.1	4.000	37.000	9.610	2.480	92.440	36.840

The Maize model included into DSSAT is CERES-Maize, and has been tested and used by many researchers around the world for various applications. CERES is a family crop-soil-climate computer model at the core of computer software (DSSAT) (IBSNAT, 1994). DSSAT integrates these crop models to asses yield, resource use and risk associated with different crop production practices.

Therefore to use DSSAT as a tool for management decisions in sustaining economically and environmentally safe agriculture, the CERES-Maize needs to be evaluated and calibrated in the Guinea savanna agro ecological conditions where this experiment was carried out.

The general objective of this study was to update and refine fertilizer recommendations for maize in the Guinea savanna agro-ecological zone of Ghana, using short term field experiments and DSSAT V 4.5. Although the DSSAT model can synthesize information quickly and inexpensively, the reliability of the model is based on the degree to which the model accurately reflects the natural process.

In sub-Saharan Africa, maize is a staple food for an estimated 50 % of the population and provides 50 % of the basic calories. It is an important source of carbohydrate, protein, iron, vitamin B, and minerals. Africans consume maize as a starchy base in a wide variety of porridges, pastes, grits, and beer. Green maize (fresh on the cob) is eaten parched, baked, roasted or boiled and plays an important role in filling the hunger gap after the dry season. Maize grains have great nutritional value as they contain 72 % starch, 10 % protein, 4.8 % oil, 8.5 % fibre, 3.0 % sugar and 1.7 % ash (Chaudhary, 1983). Zea mays is the most important cereal fodder and grain crop under both irrigated and rainfed agricultural systems in the semi-arid and arid tropics (Hussan et al., 2003). The per capital consumption of maize in Ghana in 2000 was estimated at 42.5 kg (MoFA, 2000) and an estimated national consumption of 943000 Mt in 2006 (SRID, 2007).

Over the last 30 years, fertilizer consumption in sub-Saharan Africa has increased. In recent years, growth in fertilizer on cereals, particularly maize has contributed substantially to this increase. Nonetheless, current application rates remain low. Fertilization in tropical agriculture has the potential to dramatically increase production due to the highly weathered soils and the limited reserves of nutrients (Stewart et al., 2005), yet increased nutrient application is rarely managed by recommendations derived from soil testing and consequently this leads to misuse and associated economic (Chase et al., 1991) and environmental risks (Bundy et al., 2001; Cox and Lins, 1984). In Ghana currently the importers of fertilizers to the various sectors of food production and other uses are numerous with a growing interest in the fertilizer import business.

The end users of fertilizers in the food production sector of Ghana, consists of a large number of small scale farmers in units of large households especially in the Northern, Brong Ahafo and parts of the Ashanti region. With proper education, affordable price, timely availability and accessibility, demand for fertilizers in Ghana is enormous.

Farmers make decisions that are surrounded by natural and economic uncertainties, mainly weather and prices. Agricultural research is designed to provide information that will help the farmer in making such decisions. The weakness of this approach and the need for greater in-depth analysis has long been recognized (Hamilton et al., 1991).

Recently, application of a knowledge-based systems approach to agricultural management has been gaining popularity due to the growing knowledge of processes involved in plant growth, and the availability of inexpensive powerful computers (Jones, 1983). The system approach makes use of dynamic simulation models of crop growth and cropping systems. Simulation models that can predict crop yield, plant growth and development, and nutrient dynamics offer good opportunities for assisting, not only farm managers, but also regional decision makers in several aspects of decision making. Regional policy decision related to agriculture involves maintenance of an adequate supply and quality of water for domestic and industrial consumption (Lecler, 1998). Agriculture is usually the major user of water of a region and a large quantity of chemicals are applied to the land. Thus making rational decisions regarding the impact of agricultural practices on the non-agricultural segment of the society is important.

Computerized decision support systems are now available for both field-level crop management and regional level productions. The Decision Support System for Agro-technology Transfer (DSSAT) is an excellent example of such a management tool. It enables users to match the biological requirement of a crop to physical characteristics of the land to achieve specific objective(s).

II. Materials and Methods

a) *Study area*

The study was carried out in the Northern region of Ghana. The field experiment was done at Kpalesawgu, a suburb of Nyankpala near the Savanna Agricultural Research Institute's experimental field. The site is located about 16 km west of Tamale and lies on latitudes N 090 24' 15.9''and longitude W 0010 00' 12.1''of the interior Guinea Savanna agro-ecological zone of Ghana, which has a mean daily temperature of 26 ^{0}C (SARI, 1996). The area has a uni-modal rainfall pattern averaging about 1100 mm annually (Dankyi *et al*., 2005). The Guinea Savanna zone was strategically selected for a number of reasons: (i) it is an important breadbasket area (ii) it is an important growing area for maize, (iii) the highest concentration of past soil fertility management research is located within this area, (iv) the nearness to large local and regional markets for inputs and outputs. The study covered a period from June to December 2010.

b) *Experimental Design*

A randomized complete block design with four replications was used. The plot size was 5.0m × 15.0 m with plant spacing of 80 cm × 40 cm. Treatments applied were N-P_2O_5-K_2O 0-0-0, 40-60-60, 80-60-60, 120-60-60, 150-60-60, 120-0-60, 120-45-60, 120-90-60, 120-60-0, 120-60-45 and 120-60-90 kg/ha.

The blocks were arranged from east to west with eleven plots each and a surface area of 75 m^2 (15 m long and 5 m wide) separated by 1m alley and has eight rows per plot. The plants were monitored and phenological data as well as management information were collected. These include sowing date, date of fertilizer application, date of flag leaf stage, date of flowering, date for grain filling and date of maturity. The phonological stages were noted when 50% of plant population attained that stage. Final total biomass and grain yield were also measured from a plot size of 9m2 by harvesting above-ground biomass and separating them into the various components according to the procedure described in Hoogenboom *et al*. (1999). Grain yield and total biomass were expressed in t ha–1. Soil samples (both disturbed and undisturbed) were taken at different horizons (0–10, 10–20, 20–30, 30–40, 40–50, 50-60, 60-70, 70-80, 80-90, 90-100, 100-110, 110-120, 120-130, 130-140, and 140-150 cm). Soil organic carbon, pH, soil particle distribution, wilting point, field capacity, bulk density and saturation were all determined as described in Hoogenboom *et al*. (1999), (Table 1and Table 2).

Table 3 : Monthly total rainfall, monthly means,solar radiation, sunshine hours, maximum and minimum temperature between 1971-2010 at Tamale, Ghana used for running the model.

Month	SRad($MJm^{-2}\ d^{-1}$)	Tmax(^{0}C)	Tmin(^{0}C)	Rain	Nwet	SunH
Jan	11.0	35.1	18.8	2.3	0.2	7.4
Feb	11.8	37.2	21.8	8.1	0.6	7.5
Mar	12.4	37.7	24.9	38.4	3.1	7.3
Apr	12.5	36.2	25.2	70.3	5.3	7.3
May	12.2	34.1	24.2	117.9	8.1	7.3
Jun	11.9	31.9	23.0	133.0	9.5	7.1
Jul	11.9	30.2	22.8	161.7	10.6	6.8
Aug	12.1	29.6	22.6	185.7	12.6	6.6
Sep	12.2	30.2	22.4	214.1	14.4	6.9
Oct	11.9	32.2	22.6	85.5	7.6	7.4
Nov	11.3	34.9	21.5	11.6	0.9	7.8
Dec	10.7	34.6	19.2	3.0	0.3	7.4

The experimental field had been under fallow since 2008. Before then sorghum was planted. The land was ploughed, harrowed and ridged. Maize variety *Obaatanpa* was planted on 18th June, 2010 with a spacing of 80 cm x 40 cm.

Three seeds were planted and later thinned to two plants/ hill. Thinning was done before fertilizer was applied.50% of the nitrogen and all the phosphorus and potassium were applied two weeks after planting. The remaining nitrogen was applied five weeks after planting. The fertilizer was banded on both sides of the plant and buried.

c) Model Calibration

A calibration of a model can generally be defined as an adjustment of some parameters and functions of a model so that predictions are the same or at least very close to data obtained from field experiments (Penning de Vries, 1989). For crop growth models the calibration involves determining genetic coefficients for the cultivar (Table 4) to be grown in a location. For the current study various crop growth development parameters were used to calibrate DSSAT. These values include silking date, physiological maturity date (black layer formation), grain weight, number of grains per plant and number of grains per square meter.

The calibration procedure of the CERES-Maize model consisted of making initial estimates of the genetic coefficient and running the model interactively, so that simulated values match as closely as possible the measured data. The values of the thermal time from seed emergence to the end of the juvenile stage (P1), the photoperiod sensitivity coefficient (P2), and the thermal time from silking to maturity (P5), were computed using observed silking and physiological maturity dates. Potential kernel number plant-1 (G2) and grain growth rate (G3) are input parameters to determine the potential grain yield. The DSSAT model acts to reduce this potential as a result of suboptimal environmental conditions. As suggested by Kiniry (1991), when these values are not obtained in these conditions, an alternative is to calibrate these parameters by running the model on existing data sets. The calibration procedure was performed using the GENCALC in DSSAT (Hunt et al., 1994).

Table 4 : The genetic coefficients of used for modeling the *obaatanpa* maize variety in CERES-maize model at Kpalesawgu, Ghana

Codes	Definitions	Values
P1	Thermal time from seedling emergence to the end of the juvenile phase during which the plant is not responsive to changes in photoperiod (expressed in degree days).	320.00
P2	photoperiod sensitivity coefficient	0.100
P5	Thermal time from beginning of grain filling to physiological maturity (expressed in degree days).	945
G2	maximum kernel number plant-1	350
G3	potential kernel growth rate	8

d) Statistical Evaluation and Model Validation

Despite the fact that a considerable amount of information on agricultural modeling has been published in the last decades, there is no standard methodology to evaluate the predictive ability of a model. In fact, it has been subject to a considerable debate (15). As attempts to evaluate these models have increased, various ways of evaluation has been suggested (16, 17, 18; 19). For the present study the methods of Addiscott and Whitmore (1987) and Willmott (1982) were followed to analyze simulation accuracy.

An analysis of the degree of coincidence between simulated and observed values were carried out by using Root Mean Square Error (RMSE)(18), and the ratio of RMSE over the average (Stockel*et al*., 1997), Loague and Green 1991), Mean Difference (MD). The RMSE has been widely used as a criterion for model evaluation (Ma *et al* 1998, Retta*et al* 1996, Kiniry*et al* 1997, Jemison *et al* 1994, Legnick*et al* 1994). RMSE is calculated by:

$$\text{RMSE} = \sqrt{1/N\sum(Oi - Pi)2}$$

Where P and O are the predicted and observed values for the observation, and N is the number of observation within each treatment. RMSE is measure of the deviation of the simulated from the measured values, and is always positive. A zero value is ideal. The lower the Value of RMSE the higher the accuracy of the model prediction.

The MD is a measure of the average deviation of the predicted and observed values and is calculated by:

$$\text{MD} = 1/N \sum (Oi - Pi)$$

The positive and negative signs of the MD reflect that, on average, the model is overestimating or under estimating the observed values, respectively. A t-test was used to determine whether MD is significantly different from zero (Addiscott and Whitmore 1987).

e) Weather

Weather data used by the model in running simulations were daily rainfall amount, daily solar radiation, minimum and maximum daily temperature. A summary of weather parameters for the growing season is presented in Table 3. These were collected from a weather station located in the study area. Forty years historical weather data for the study area were used as input data for the DSSAT Weatherman to simulate 40 years weather data for the study area. This was used to evaluate the impact of weather on crop, nutrient and water productivity.

Table 5 : Observed yield of maize, total biomass, stover and unit grain weight in response to mineral fertilizer application in Kpalesawgu, Ghana

Treatment Kg/ha N-P_2O_5- K_2O	Unit grain wt. (g)	Tot Biomass (kg/ha)	Stover (kg/ha)	Yield (kg/ha)
0-0-0	0.338	764	533	231
40-60-60	0.465	7301	6092	1208
80-60-60	0.513	9627	7124	2503
120-60-60	0.475	10181	6392	3789
150-60-60	0.513	10431	6909	3522
120-0-60	0.435	2313	1055	1258
120-45-60	0.510	9940	6701	3239
120-90-60	0.478	11392	7562	3831
120-60-0	0.483	9537	6223	3314
120-60-45	0.515	9975	6203	3772
120-60-90	0.480	10374	6796	3578

III. Results and Discussions

a) Grain yields

Grain yield measured ranged from 231 kg/ ha^{-1} when no mineral N fertilizer was applied, to 3831 kg/ ha^{-1} at 120-90-60 kgN-P_2O_5-K_2O ha^{-1} application in the field. (Table5). Significant (p=0.05) grain yield increases in maize cultivation were observed between the all levels of mineral fertilizer application. The low yields in the control which is a normal practice of farmers explain their reluctance to cultivate mineral fertilizer. The yield gaps between the no application plots and the mineral fertilizer were not compensated for by the application of as much as 120 $kgNha^{-1}$ an indication that mineral N is not the only yield limiting factor. This means that mineral fertilizer alone cannot solve crop production problems on poor soils. Yield differences are more likely to be attributed to the differences in their soil fertility (Table 1). Thus, for improved crop production, mineral fertilizer must be complemented with measures to increase soil organic carbon as it is highly associated with fertility.

b) Validation of the Model

i. *Data available for model validation*

Data for model validation include silking and maturity dates, grain yield, grain weight, and above ground biomass.

ii. *Simulation of the field experiment*

Comparison between measured and predicted maize yield showed good agreement. The NRMSE was 0.181 (Loague and Green, 1991). Comparison between predicted and simulated yield at harvest maturity for all treatments is presented in Figure 1.

Simulated and observed grain yield for 120-60-60, 150-60-60 and 120-90-60kg/ha N-P-K were 3795.0 and 3789 kg/ha, 3646and 3522.0 kg/ha, 3990 and 3831 kg/ha, respectively.

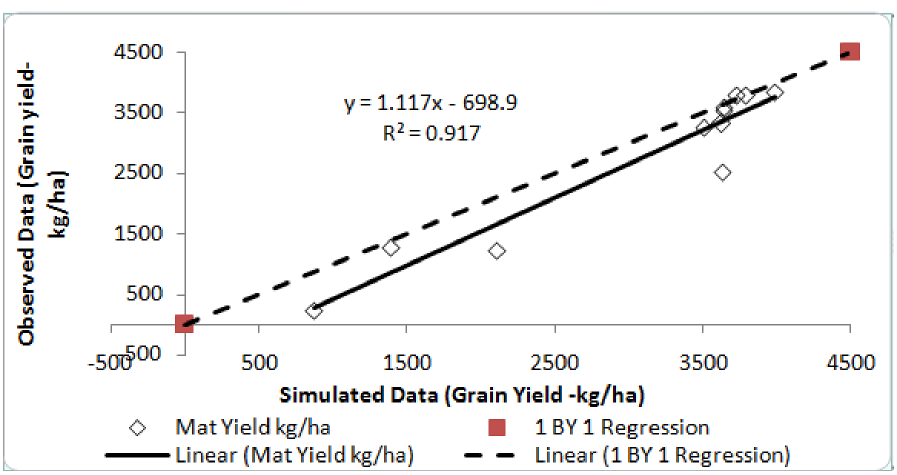

Figure 1 : Comparison of grain yield predicted by the DSSAT model with measured values.

Even though 120-90-60 kg/ha N-P-K gave the highest mean yield, there was no significant (Lsd=0.05) difference between predicted and observed mean yields when 120-60-60 kg/ha N-P_2O_5-K_2O was applied. Both simulated and observed mean harvest maturity yields increased with increased N and P. However, the effect of K on mean yield was minimal. This suggests that K is not limiting in soils in the Guinea savanna agro-ecological zone of Ghana.

Results of simulated and measured top weight at maturity and by-product produced at maturity for all treatments are presented in Figures 2 and 3 respectively. Similarly the model prediction for top weight at maturity and by-product produced at maturity was considered excellent with NRSME of 0.097 and 0.090 (Loague and Green, 1991) respectively. Thus the model prediction was in close agreement with measured values.

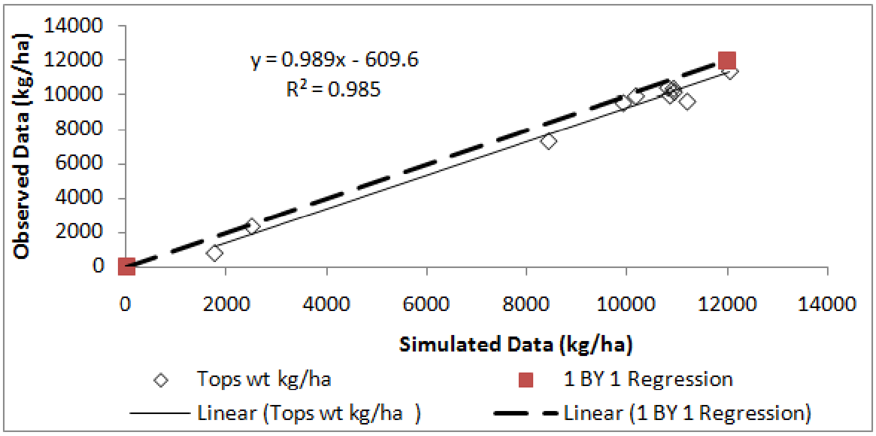

Figure 2 : Comparison of top weight at maturity predicted by the DSSAT model with measured values.

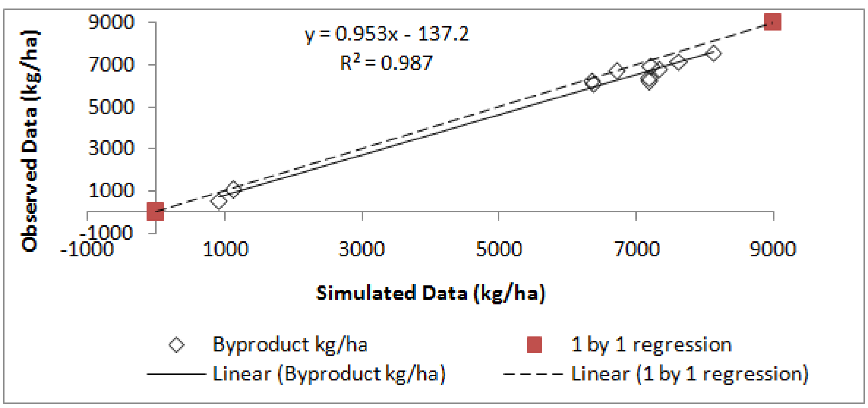

Figure 3 : Comparison of by-product produced at maturity predicted by the DSSAT model with measured values.

The DSSAT model under predicted days to physiological maturity (Figure 4). Predicted values were 1-2 days earlier for all treatments except when there was no application of inorganic fertilizer. The model estimated the maturity date to be 9th October 2010. However, the observed maturity dates were between 8th - 12 October 2010. The DSSAT model failed to account for the rapid growth optimized by the N and thus assumed one maturity date for all the treatment. Model performance was mixed in predicting the harvest index. It under predicted for plots with high levels of fertilizer and over predicted for plots with low fertilizer rates.

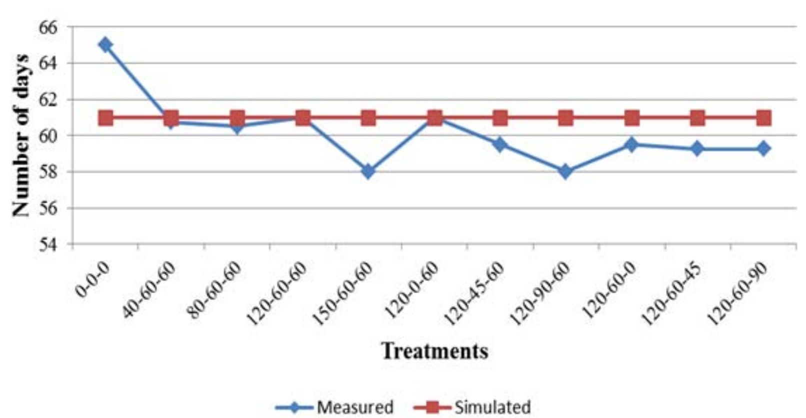

Figure 4 : Comparison of Anthesis (DAP) predicted by the DSSAT model with measured values

c) Statistical evaluation and model validation

Although yield at harvest maturity, top weight at maturity and by-product produced at maturity were calibrated with data measured in the experimental field, simulated values were slightly over predicted by the model. A summary of statistical analysis of the results of these variables is presented in Table 6.

Table 6 : Comparison of mean values of selected field observations and their simulations for the growing season

Variable Name	*Mean*		*SD*		*r-Square*	*MD*	*RMSE*	*NRMSE*	*d-Stat.*
	O[d]	S[d]	O[d]	S[d]					
Byproduct (kg/ha)	5599	6017	2305.74	2402.81	0.987	418.0	505.450	0.090	0.989
Tops weight (kg/ha)	8349	9052	3362.02	3373.20	0.986	704.0	810.352	0.097	0.986
Harvest index	0.340	0.37	0.09	0.08	0.529	0.0	0.067	0.197	0.833
Mat Yield (kg/ha)	2750	3086	1211.37	1038.41	0.918	336.0	498.771	0.181	0.952
Weight (g/unit)	0.4745	0.31	0.005	0.030	0.870	-0.2	0.169	0.356	0.358

Significant at P ≤0.005 Significant at P≤0.001Od- Observed dataSd- Simulated data MD-Mean difference SD- Standard deviationRMSE- Root Mean Square Error*

Model prediction for by-product produced at maturity, top weight at maturity and maize grain yield at maturity were considered excellent withRMSE value of 505.45, 810.35 and 498.77, respectively (Wallach and Goffinet, 1987). Predicted and observed mean harvest maturity yield were 3086 and 2750 kg/ha with a standard deviation of 1211.37 and 1038.41 respectively (Table 6).

d) Water resource productivity

Results of the effect of different levels of N, P and K on water productivity are presented in Figure 5a-5c.Results of simulated and observed water productivity showed that water productivity increases when N levels are increased. Water productivity was however inefficient when 150 kg/ha N was applied (Figure 5a).

The effect of K on predicted and observed Water productivity was minimal (Figure 5b). This is to be expected since according to the experimental results, the mean differences in yield was not significant (lsd=0.05) when 45 and 60 kg/ha K were applied. The order magnitude of P effect is similar to that of N (Figure 5b).Higher values of water productivity are obtained when evapotranspiration (ET) is used rather than rainfall (Figures. 5a-c). This is because not all the rain water is used by the crop as some may be lost through direct evaporation, run off and deep percolation. In general the data showed that rainwater productivity can be greatly improved when soil fertility is increased. Other ways of increasing water productivity is by insitu rainwater harvesting through tied-ridges (Fosuet *al*., 2008).

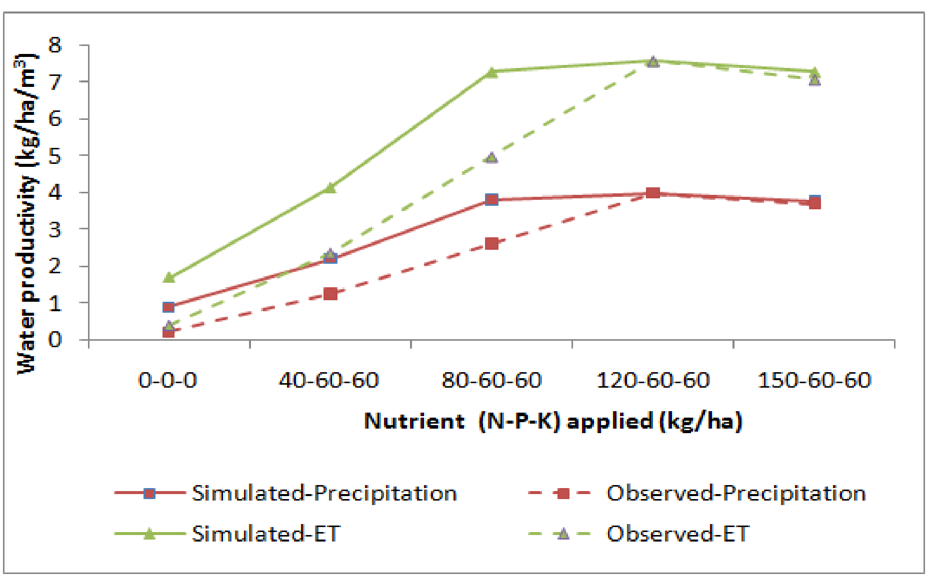

Figure 5a : Relationship between predicted and observed water productivity at different levels of nitrogen application.

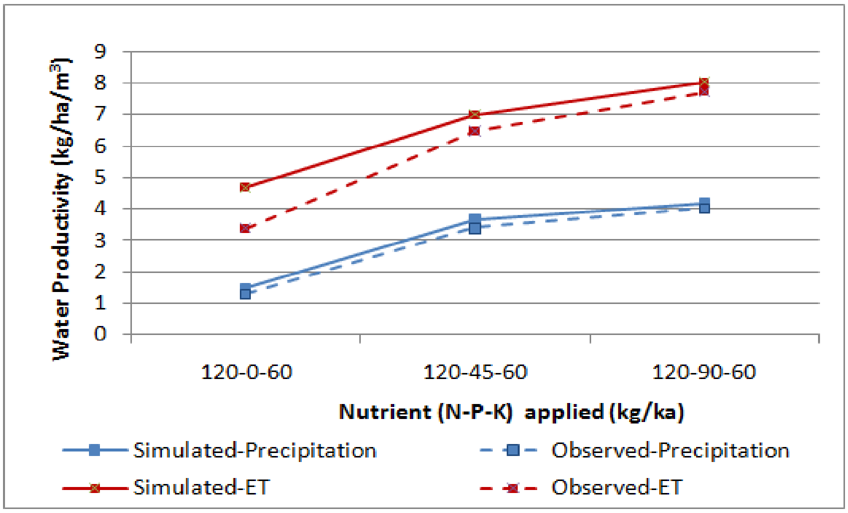

Figure 5b : Relationship between predicted and observed water productivity at different levels of P application.

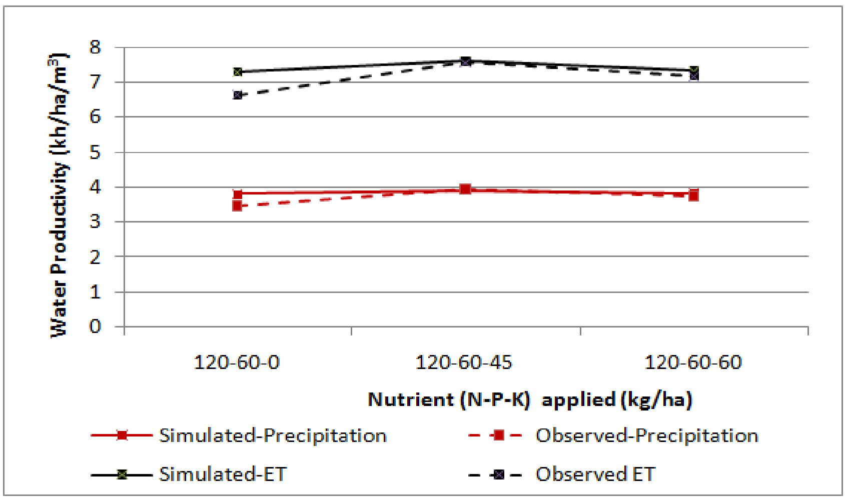

Figure 5c : Relationship between predicted and observed water productivity at different levels of K application.

e) *Seasonal analysis*

i. *Biophysical analysis*

Results of biophysical simulation of yield conducted by the DSSAT model over a 40 year period is presented in Table 7. The results indicate minimum and maximum yield within the 40 year period of simulation with their mean yields and standard deviations. 120-90-60 kg/ha N-P_2O_5-K_2O recorded the highest yield of 4182 kg/hawith a mean yield and standard deviation of 2860 kg/ha and 713, respectively.

Table 7 : Simulation of maize yield by DSSAT over a 40 year period

Treatment N-P_2O_5-K_2O (kg/ha)	Mean	St Dev.	Yield (kg/ha)	
			Minimum	Maximum
0-0-0	502.22	129.2	169	890
40-60-60	1654.7	323.9	1184	2316
80-60-60	2552.9	480.3	1271	3427
120-60-60	2799.1	662.6	1408	4136
150-50-60	2708.1	666.6	1321	4028
120-0-60	596.1	116.3	395	954
120-45-60	2510.6	623.7	1286	3987
20-90-60	2860.1	713.5	1269	4182
120-60-0	2589.1	633.1	1264	3622
120-60-45	2672	652.5	1204	3920
120-60-90	2714.1	688.6	1204	4155

Meanwhile, the minimum yield obtainable when the above treatment was applied is 1269 kg/ha. However 4136 kg/ha maximum yield was also obtained when 120-60-60 kg/ha N-P2O5-K2O was applied with mean yield and standard deviation of 2799 kg/ha and 662, respectively (Table 7).

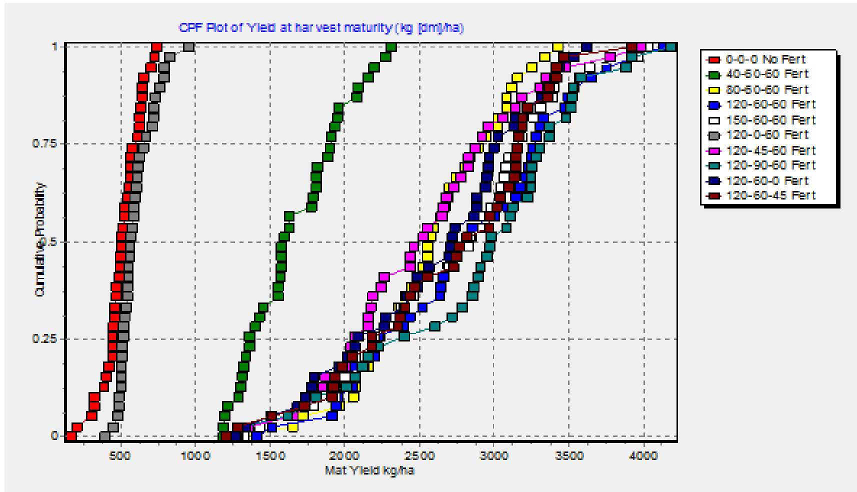

Figure 6 : Cumulative probability function plot of yield at harvest maturity for a 40 year period.

Result of cumulative probability of attaining harvest grain yield by specific treatment is presented in Figure 3.8.2. For instance at 75% cumulative probability, the maximum average maize grain yield of 600, 1800 and 3200 kg/ha were obtained when 0-0-0, 40-60-60 and 120-90-60 kg/ha N-P_2O_5-K_2Owere applied. This implies that at 75% of the 40 year simulation, no matter the management and or agronomic practices that is employed, maize grain yield cannot exceed 600, 1800 and 3200 kg/ha on application of 0-0-0, 40-60-60 and 120-90-60 kg/ha N-P_2O_5-K_2O.

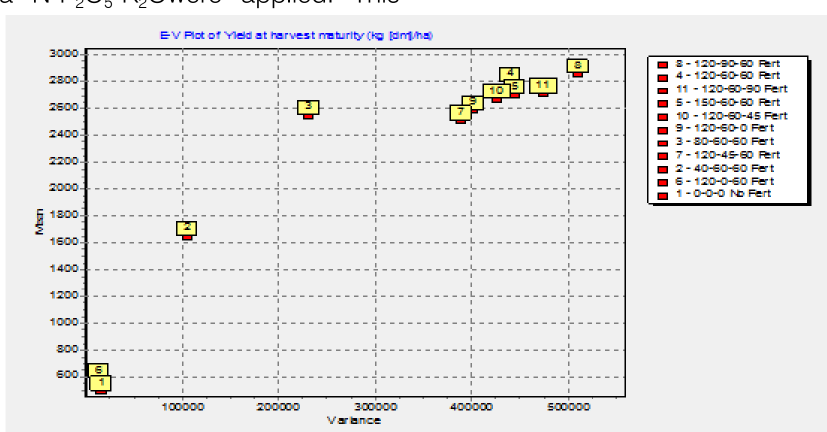

Figure 7 : Mean-Variation of yield at harvest maturity (kg [dm]/ha)

Results of variability in attaining predicted average harvest yield is presented in Figure 7. Treatments 1 and 6 present the least variability in obtaining their corresponding average harvest maturity yield. The results showed that when no fertilizer was applied (0-0-0 kg/ha N-P_2O_5-K_20), obtainable yield range is limited but increases when fertilizer is applied (Figure 7). Treatment 6 (120-0-60 kg/ha N-P_2O_5-K_20) showed that P is very limiting in the soil and even with high levels of N, yield cannot be increased significantly in the absence of P. Therefore treatments with higher average harvest maturity yield with less variability in obtaining them are considered the best. Treatment 8 recorded the highest mean yield and variation of 2900 kg/ha and 500000, respectively.

IV. Conclusion

In general, maize yield simulation by DSSAT under Guinea savanna agro-ecological conditions was good. Average predicted harvest maturity yields were very close to measured values with MD of 336.0, RMSE of 498.77, NRSME of 0.181 and simulated and observed mean yields of 3096 and 2750 kg/ha for the entire treatments respectively. The mean difference between predicted and observed was not significant.

The highest harvest maturity yield predicted and observed was achieved with 120-90-60 kg/ha N-P_2O_5-K_2O. The predicted and observed average mean yield were 3831 and 3999 kg/ha, respectively. Based on the simulation results from this study the DSSAT model appeared to be suitable for the Guinea savanna agro-ecological conditions in Ghana. However, the model performance in simulation for a long term basis needs to be evaluated.

There was scarcity of detailed field data e.g. leaf area index, tops N at anthesis, grain N at anthesis etc. for adequately evaluating the model. Therefore, a field experiment should be setup in other areas of the GSAZ for calibrating and validating major subroutines of the model including soil water balance components.This study recommends120-90-60 kg/ha N-P_2O_5-K_2O as the most economically and strategically efficient fertilizer rate that gives maximum yield and maximum returns at Kpelsawgu in the Guinea savanna agro-ecological zone of Ghana. However, 80-60-60 and 120-60-60 kg/ha N-P_2O_5-K_2O are also recommended by this study.

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Propensity of using Harmful Gas Controller and Oxygen Supplier on the Basis of Fish Farmers Age, Educational Status and Landownership of Six Upazilas in Noakhali District, Bangladesh

By Md. Mosleh Uddin, Bhakta Supratim Sarker, K. M. Shahriar Nazrul & Umma Salma Tonny

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Abstract- The intensity of aquaculture is increasing day by day in Bangladesh. To meet the increasing demand new technologies are being used to enhance production. Recently the use of fish medicines in aquaculture is also seen among the farmers of our country. In the present study, the propensity of using harmful gas controller and oxygen supplier on the basis of farmers' age, educational status and land ownership were studied. The study was conducted in six upazilas of Noakhali district, Bangladesh. Data were collected through questionnaire survey of 77 fishermen by interviewing with them and discussing with the upazila fisheries officer, retailers of fish medicines and representatives of pharmaceutical companies and market survey.

Keywords: *harmful gas controller, oxygen supplier, educational status, landownership.*

GJSFR-D Classification : *FOR Code: 070799*

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Md. Mosleh Uddin [α], Bhakta Supratim Sarker [σ], K. M. Shahriar Nazrul [ρ] & Umma Salma Tonny [ω]

Abstract- The intensity of aquaculture is increasing day by day in Bangladesh. To meet the increasing demand new technologies are being used to enhance production. Recently the use of fish medicines in aquaculture is also seen among the farmers of our country. In the present study, the propensity of using harmful gas controller and oxygen supplier on the basis of farmers' age, educational status and land ownership were studied. The study was conducted in six upazilas of Noakhali district, Bangladesh. Data were collected through questionnaire survey of 77 fishermen by interviewing with them and discussing with the upazila fisheries officer, retailers of fish medicines and representatives of pharmaceutical companies and market survey. The propensity of using harmful gas controller was higher than any other medicines used by farmers of all upazilas surveyed. In the case 36% farmers showed their tendency to use, because most of the farmers had problems with harmful gases in their ponds. In case of oxygen supplier 22% farmers used oxygen in their ponds. Most of the farmers' age ranged between 26-35 and 36-45 years who showed more tendencies to apply both medicines in their ponds. It was also found that the farmers whose education level was above higher secondary school certificate (HSC) showed more tendency to apply medicines. Farmers who were rich having 6 and above acres of land showed more tendencies than poor and moderately rich farmer to apply medicines in their ponds. The study clearly showed that, there was a relationship between farmers' age, educational status and land ownership with the adoption of harmful gas controller and oxygen supplier.

Keywords: harmful gas controller, oxygen supplier, educational status, landownership.

I. Introduction

Bangladesh is one of the world's leading inland fisheries producers with a production of 2381916 mt, marine fish production of 517282 mt and a total production from closed water body of 1351979 mt (DoF, 2011).

In advance of fish cultivation the use of medicine is also increasing. The rationale of this study was to find out whether there was any relationship between this increasing fish cultivation and harmful gas controller and oxygen supplier usage with that of age, educational status and land ownership of the farmers. As a model district Noakhali was selected, which is famous for its vast area of watery resources located in the Chittagong division, Bangladesh having a land area of 3600.99 km^2. A number of studies did not find strong evidence to support the hypothesis that age of the farm operator has an impact on the adoption decision (Boz and Akbay, 2005; Daberkow and McBride, 2003). There are also a large body of works that documents a strong, positive correlation between education and measures of health but little is known about the mechanisms by which education might affect the adoption of new technologies as well as chemical use. So, the specific objective of the experiment was to identify the propensities of using harmful gas controller and oxygen supplier in aquaculture activities by fish farmers on the basis of their age, educational status and land ownership.

II. Materials and Methods

a) *Research approach and technique*

The quantitative data were collected by structured survey while qualitative information was explored by case studies as the primary tools of data collection following Blaxter *et al*. (1996). Both types of research were important and useful although they were not mutually exclusive.

b) *Research design*

The design of the survey for the present study involved some necessary steps, which are outlined in fig.1:

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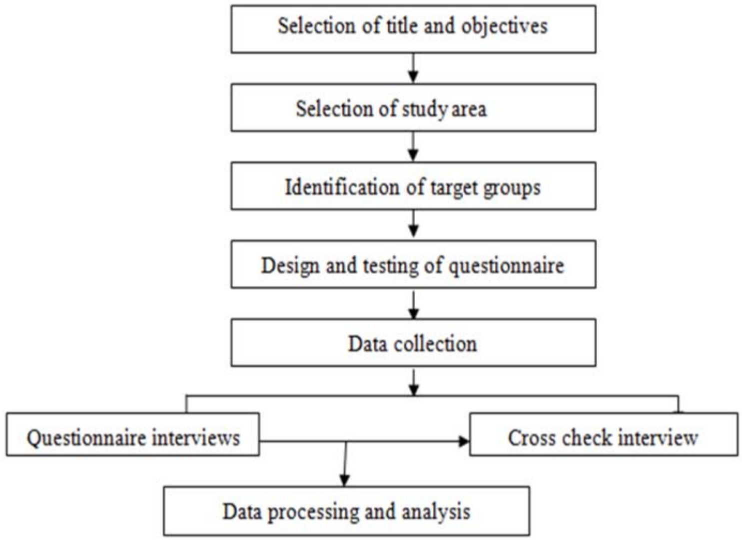

Figure 1 : Flow chart of the research design

c) *Study area selection*

There are 9 upazilas in Noakhali district, Bangladesh. 6 upazilas among them were selected due to the convenience of communication from university campus (Noakhali Science and Technology University). The selected upazilas were Begumganj, Chatkhil, Companiganj, Kabirhat, Noakhali Sadar and Subarnachar.

d) *Sampling and data collection*

77 farmers were interviewed in 6 selected upazilas. The interview was taken from farmers when they were administering medicine in the pond, chatting with each other in different locality and purchasing medicine in fish medicine store and different fish markets. Farmers list was collected from upazila fisheries office and fish medicine companies. After that the farmers were classified in different age groups from 15 to 65 years.

e) *Frequency distribution on the basis of upazila*

Frequency of the farmers and their percentages distribution among 6 upazilas are shown in table 1.

Table 1 : Distribution of the fish farmers according to the upazila.

Upazila name	Frequency	Percentage
Begumganj	10	13.0
Chatkhil	12	15.6
Companiganj	12	15.6
Kabirhat	11	14.3
Noakhali Sadar	26	33.8
Subarnachar	6	7.8
Total	77	100

f) *Categorization of farmers on the basis of age*

According to 10 years interval the total farmers were classified into 5 categories (table 2).

Table 2 : Distribution of fish farmers according to age.

Age interval	No. of the interviewee	Percentage of the interviewee
16-25	14	18.2
26-35	24	31.2
36-45	24	31.2
46-55	9	11.7
56-65	6	7.8
Total	77	100

g) *Categorization of farmers on the basis of farmers' educational status*

Farmers were classified into 5 different categories according to their educational status (table3).

Table 3 : Distribution of fish farmers according to educational status.

Educational Status	No. of interviewee	Percentage of the interviewee
No education	4	5.2
Primary	27	35.1
SSC	19	24.7
HSC	14	18.2
Above HSC	13	16.9
Total	77	100

h) Categorization of farmers on the basis of farmers land ownership

Farmers were classified into 3 groups according to the quantity of land they owned (table 4).

Table 4 : Distribution of fish farmers according to the land ownership.

Quantity of land owned (acre)	Categorization of farmers	Frequency	Percentage
1-2.9	Poor farmers	34	44.2
3-5.9	Moderately rich farmers	19	24.7
6+	Rich farmers	24	31.2
	Total	77	100.0

i) Data analysis

The questions were post coded when needed, entered on the computer using Microsoft excel, checked after entry and analyzed using statistical software version (15.0) SPSS. Descriptive statistics was used for analysis and presentation of data.

III. Results

a) Use of harmful gas controller

Harmful gas controller is used to control the obnoxious gas in the bottom of the pond, to develop the environment of the pond, to save fish from the diseases. Some of the drugs used in Noakhali district were Zeolite, Gasonex, Aquamagic, Megazeo, Geotox etc.

i. Use of harmful gas controller on the basis of upazila

From the study it was observed that 10% farmers of Begumganj upazila, 50% of Chatkhil upazila, 55% of Kabirhat upazila, 42% of Noakhali sadar upazila, 67% of Subarnachar upazila used harmful gas controller. However, in Companiganj upazila no farmer was seen to use it (table 5).

Table 5 : Distribution of harmful gas controller user on the basis of upazila.

Upazila Name	Harmful Gas Controller				Total
	Non user	Percentage	User	Percentage	
Begumganj	9	90	1	10	10
Chatkhil	6	50	6	50	12
Companiganj	12	100	0	0	12
Kabirhat	5	45	6	55	11
Noakhali sadar	15	58	11	42	26
Subarnachar	2	33	4	67	6
Total	49	64	28	36	77

ii. Use of harmful gas controller on the basis of age

Farmers of early ages showed higher tendency to use harmful gas controller in their ponds. Thus the farmers of age range 16 -25 used more drugs in comparison to others (table 6).

Table 6 : Distribution of harmful gas controller user on the basis of age.

Age Interval	Harmful Gas Controller				Total
	Non user	Percentage	User	Percentage	
16-25	8	57	6	43	14
26-35	15	62	9	38	24
36-45	15	62	9	38	24
46-55	6	67	3	33	9
56-65	5	83	1	17	6
Total	49	64	28	36	77

iii. *Use of harmful gas controller on the basis of educational status*

The farmers who had no education showed no tendency to use these medicines (table 7).

Table 7 : Distribution of harmful gas controller user on the basis of educational status.

Educational Status	Harmful Gas Controller				Total
	Non user	Percentage	User	Percentage	
No education	4	100	0	0	4
Primary	23	85	4	15	27
SSC	12	63	7	37	19
HSC	4	28	10	72	14
Above HSC	6	46	7	54	13
Total	49	64	28	36	77

iv. *Use of harmful gas controller on the basis of land ownership*

From the study it was known that 24% farmer having 1-2.9 acre land, 37% having 3-5.9 acre land and 54% farmer having above 6 acre land had tendency towards harmful gas controller using (table 8).

Table 8 : Distribution of harmful gas controller user on the basis of land ownership.

Land Ownership	Harmful Gas Controller				Total
	Non user	Percentage	User	Percentage	
Poor farmer	26	76	8	24	34
Moderately rich farmer	12	63	7	37	19
Rich farmer	11	46	13	54	24
Total	49	64	28	36	77

b) *Use of oxygen supplier*

Oxygen supplier is a medicine which supplies essential oxygen to water body. The usefulness of using this medicine is to regulate the growth of phytoplankton, save the fish from parasite, and maintain the nutrients of the water body.

i. *Use of oxygen supplier on the basis of upazila*

It was found that no farmer used oxygen in their pond in Kabirhat upazila, whereas 20% used in Begumganj upazila, 25% in Chatkhil upazila, 8% in Companiganj upazila, 17% in Subarnachar upazila and maximum 39% farmers in Noakhali sadar upazila (table 9).

Table 9 : Distribution of Oxygen supplier user on the basis of upazila.

Upazila Name	Oxygen Supplier				Total
	Non user	Percentage	User	Percentage	
Begumganj	8	80	2	20	10
Chatkhil	9	75	3	25	12
Companiganj	11	92	1	8	12
Kabirhat	11	100	0	0	11
Noakhali sadar	16	61	10	39	26
Subarnachar	5	83	1	17	6
Total	60	78	17	22	77

ii. *Use of oxygen supplier on the basis of age*

According to the study, middle aged farmers used more oxygen supplier in their ponds (table 10).

Table 10 : Distribution of Oxygen supplier user on the basis of age.

Age Interval	Oxygen Supplier				Total
	Non user	Percentage	User	Percentage	
16-25	13	93	1	7	14
26-35	18	75	6	25	24
36-45	18	75	6	25	24
46-55	6	67	3	33	9
56-65	5	83	1	17	6
Total	60	78	17	22	77

iii. *Use of oxygen supplier on the basis of educational status*

Some variations were seen in case of oxygen supplier use among farmers. 25% of farmer who had no education used these, 11% of primary educated farmer, 26% in case of SSC level, 14% in case of HSC level and as usual the 46% farmers whose education level is above HSC used oxygen supplier (table 11).

Table 11 : Distribution of Oxygen supplier user on the basis of educational status.

Educational Status	Oxygen Supplier				Total
	Non user	Percentage	User	Percentage	
No education	3	75	1	25	4
Primary	24	89	3	11	27
SSC	14	74	5	26	19
HSC	12	86	2	14	14
Above HSC	7	54	6	46	13
Total	60	78	17	22	77

iv. *Use of oxygen supplier on the basis of land ownership*

Poor famers had little tendency to use oxygen while rich farmer showed more tendency to apply it (table 12).

Table 12 : Distribution of Oxygen supplier user on the basis of land ownership.

Land Ownership	Oxygen supplier				Total
	Non user	Percentage	User	Percentage	
Poor farmer	28	82	6	18	34
Moderately rich farmer	15	79	4	21	19
Rich farmer	17	7	7	29	24
Total	60	78	17	22	77

IV. Discussion

Aquaculture in Bangladesh is expanding rapidly with diversification, intensification and technological improvements. Around 60% of animal protein is supplied by the commercially important fisheries organisms which are also considered as the cheapest and richest source of animal protein (DoF, 2011). To increase production which is environmentally viable is the major goal of aquaculture. The aquaculture activities in Bangladesh are also influenced by a number of chemicals. As a result, different types of chemicals are used frequently in this sector. The present study identified a range of chemicals are being used in fresh water aquaculture activities in Noakhali district. For pond preparation and water quality management, farmers used lime, zeolite, fish toxin, insecticides and different fertilizers. Lime is very effective in different purposes such as pH, water color and turbidity maintaining, increase the rate of decomposition and also act as disease treatment. Most of the farmer used lime because of its low price and effectiveness in wate quality management and it also acts against different diseases. Sultana (2004) observed that, lime is very effective and widely used common chemical in Bangladesh.

It was found that the farmers in Noakhali Sadar upazila showed more tendencies to use oxygen supplier than any other upazilas surveyed. Due to the availability of fish medicine store, medical representatives, convenience of communication and for the expert of upazila fisheries office, the farmers who use fish medicine are higher in this region. However, in case of harmful gas controller farmers were seen comparatively higher in newly formed Subarnachar upazila although the total number of farmers in Subarnachar upazila is less than any other upazilas surveyed. There are some hatcheries and fish farms which use these fish medicines for commercial purpose. Probably these fish farms influenced the farmers in Subarnachar upazila to use the medicines. The less number of farmers in Companiganj upazila were found to use harmful gas controller and oxygen supplier. In accordance with Companiganj upazila, the farmers in Begumganj and Kabirhat upazila showed no or little tendency to use medicine.

It is known that age had a negative and significant relationship with adoption level. It might be because the aged persons were less change prone and reluctant to adopt new technologies in their farms. Rogers (1995) found that the younger the farmer, the more likely he/she are to adopt innovations early in his/her respective life cycle. He also said that older farmers may have a shorter time horizon and be less likely to invest in novel technologies. Present study reveals that, average rate of aged farmer were seen to use harmful gas controller and oxygen supplier. Nelson and Phelps (1966) suggested that 'educated people make good innovators' and that 'education is especially important to those functions requiring adaptation to change'. So, more educated farmers use medicine than those of illiterate and less educated farmers. This study also reveals the same pattern.

Fernandez-Cornejo*et.al*. (2002) found that adoption rates increased with the size of the farm operation. From the result it was found that the rich farmers who have more than 6 acres land use more medicine in their farm than poor and moderately rich farmer for commercial purposes.

V. Conclusion

Aquaculture in Noakhali region is increasing rapidly and use of chemicals in aquaculture is also increasing simultaneously. If aquaculture is done in larger densities to enhance production and profit use of chemicals is must. However, some aquaculture chemicals appear to be relatively hazardous and on this basis their use should be curtailed. In the case, denying regulatory approval of the chemicals can be unnecessarily restrictive for the aquaculture industry but education, awareness rising of harmful effect of hazardous chemicals and enforcement of effluent quality limits are all among the possible approaches to ensure safe use.

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AM Fungal Protein's Contribution in Heaving Soil Physique Under Salt Stress

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Abstract- The present study was designed to test the effect of AM fungi in aggregating the soil particles against their dispersion at various levels of salt stress (L1 –1.5dSm-1; L2 – 3.0dSm-1; L3 – 4.5dSm-1) in the rhizosphere of onion. Soil quality parameters such as organic carbon content (0.61 per cent), microbial biomass carbon (327.0 mg kg -1), glomalin 119.33 (µg/ g of soil) and aggregate stability (53 per cent) were highly influenced by AM fungal inoculations. The soil bulk density and particle density were slightly brought down (1.34 and 2.52 per cent respectively) with increase in the water holding capacity and porosity (78.94 and 51.83 per cent respectively) even at third level of salt stress. In most of the cases the sodic soil isolates performed on par with the standard isolates which proved the efficacy of the isolates to compete with the standard cultures in bringing up the soil health.

Keywords: *am fungi, glomalin, micronutrient, aggregate stability, porosity.*

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Srimathi Priya [α], Kumutha [σ] & Pandiyarajan [ρ]

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I. Introduction

Increased salinization of arable land is expected to have devastating global effects, resulting in 30% land loss within the next 25 years and up to 50% by the middle of the 21st century (Wang *et al.* 2003). Approximately 7% of the global land surface is covered with saline plant habitats (Ruiz-Lozano *et al.* 1996). In semi-arid environments (which comprises of saline and sodic soils), ion toxicity because of high Na^+ and Cl^- concentrations cause destabilisation of soil structure therefore resulting in a considerable reduction in crop yield (Kohler *et al.* 2009). Soil structure is defined as the size and arrangement of particles and pores in soil (Hartge and Stewart, 1995), setting for the activity of soil biota and soil structure is hence important for soil-borne aspects of biogeochemical cycling processes (Paul and Clark, 1989). Sodium is a highly – dispersive agent causing the direct breakup of aggregates and indirectly affecting aggregation though decreased plant productivity (Bronick and Lal, 2005). Soil aggregation is a complex process that is largely dependent upon microorganisms to provide glues that hold soil particles together *via* hyphal enmeshment aggregates (Miller and Jastrow, 2000). These glues are produced by the arbuscular mycorrhizal fungus especially on their hyphae and spores that are abundant in the rhizosphere of their host plants, named glomalin. This is a glycoprotein detected in large amounts in diverse soils as glomalin-related soil protein (GRSP) and acts as the key factor in the contribution of AM fungi to soil aggregation to stabilize aggregates and influence soil carbon storage indirectly by stabilizing soil aggregates (Zhu and Miller, 2003) and therefore bring out soil stability. In alkaline soils, excessive amounts of salts, mainly sodium (Na) salts, in the soil solution cause numerous adverse phenomena such as destabilisation of soil structure, deterioration of soil hydraulic properties and a considerable reduction in crop yield (Lax *et al.* 1994 and Kohler *et al.* 2009), soil microbial biomass carbon and enzyme activities. Recently, the use of arbuscular mycorrhizal (AM) fungi as a practical way to alleviate soil stress on plant growth has received increased attention (Miransari *et al.* 2008) since it represents a living bridge for the translocation of nutrients and in particular, shown to contribute to the stability of soil aggregates, including soils of high salinity such as salt marshes (Caravaca *et al.* 2005). Their contributions to agriculture are well known, but their role in maintenance of soil structure and stability through the enhancement of soil aggregation under saline conditions in addition crop establishment has received less attention which insisted the necessity for this study. Among various preferable host of AM fungi, Onion is an important plant exhibiting excellent symbiotic relation with the fibrous root system (Poss *et al*. 1985, Cantrell and Lindermann, 2001) and hence selected for the present study. This study was undertaken to assess the diversity of AM fungi in sodic soil which basically lagged soil aggregation and soil structure.

II. Materials and Methods

This study was based on the influence of AM fungi in building salt tolerance to Onion crop and to test the effect of glomalin related soil proteins in improving the soil quality through pot culture study. Pots of 12 Kg capacity were filled with sterilized pot mix followed by AM inoculation @ 50 g^{-1} pot. Purified (sodic soil) isolates of AM (TRY 1, TRY 2, TRY 3 and TFS 1) along with two standard cultures (G. *intraradices* and S.

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calospora) were used as inoculants while control was maintained as an absolute control with salt treatment alone (without AM inoculation). The pot mix was first filled upto half the capacity of the pot followed by filling the respective AM inoculum and pot mix in alternate layers upto full capacity except for the head space of the pot. Onion bulbs were planted @ 4-5 bulbs pot^{-1} and then subjected to three levels of salt (1.5, 3.0 and 4.5 dSm^{-1}) by addition of NaCl through irrigation water twice in a week. Salt levels in the soil were maintained by checking the soil EC levels. All the treatments were replicated three times in a completely randomized design.

Inoculants:	*Salt Levels*
T1 - *Glomus intraradices*	L 1 - 1.5 dSm^{-1}
T2 - *Scutellospora calospora*	L 2 - 3.0 dSm^{-1}
T3 - TRY 1 (*Acaulospora* sp.)	L 3 - 4.5 dSm^{-1}
T4 - TRY 2 (*Scutellospora* sp.)	
T5 - TRY 3 (*Glomus* sp.)	
T6 - TFS 1 (*Glomus* sp.)	
T7 - Control (NaCl alone)	

a) Estimation of AM fungal spores in rhizosphere soil

AM fungal spore density was estimated from rhizosphere soil of Onion by wet sieving and decanting technique (Gerdemann and Nicolson, 1963).

b) Soil quality analysis

The post harvest soil was analysed for physical, chemical and biological properties. Standard methodologies (Table 1) were followed for analyzing physical and chemical properties viz., pH, EC, available N, available P and available K.

Table 1 : Standard methods followed for the physico-chemical analysis of soil samples

S. No.	Parameter	Unit	Method	Reference
II.	Physical properties			
1.	Bulk density	Mg m^{-3}	Wet cylinder method	Chopra and Kanwar (1982)
2.	Particle density	Mg m^{-3}	Wet cylinder method	
3.	Porosity	Per cent	Wet cylinder method	
4.	Water holding capacity	per cent	Keen Raczkowski Box	Piper (1966)
5	pH	-	Measured using digital pH meter	Jackson (1973)
6	EC	dS m^{-1}	Measured using conductivity bridge (CM 180 Elico conductivity Bridge)	Jackson (1973)

c) Estimation of microbial biomass carbon

Biomass carbon was determined by the fumigation-incubation technique as per the procedure given by Jenkinson and Powlson (1976). Ten g soil was weighed into 100 mL beaker. The beaker was placed in a 250 mL air tight plastic container into which about 5 mL of water was added. Ethanol free chloroform was prepared, immediately before fumigation by passing 100 mL of chloroform through a glass column containing 75 g of basic aluminium oxide. The fumigation was carried out with ethanol free chloroform for 20 hours at 25°C. After fumigation, chloroform was removed by repeated evacuations. After fumigation and removal of chloroform, the beaker holding the soil was returned to the air tight container together with a scintillation vial holding 5 mL of 0.5 N NaOH. Soil samples were inoculated with a pinch of fresh soil of respective treatments and the soil was incubated for a further period of 10 days at 25°C. Evolved CO_2 was determined by titrating the alkaline traps with 0.5 N HCl after precipitation of CO_3^{2-} with 50% $BaCl_2$ and using phenolphthalein as indicator.

$$\text{Biomass C} = (\text{C fumigated} - \text{C nonfumigated})\ CO_2 - \text{C evolved} \times K_C \text{ factor } (0.45)$$

d) Total Glomalin content

The total glomalin content in the soil was estimated according to Wright and Upadhyaya, (1996).

e) Percentage water stable aggregates

The aggregate stability percentage in soil was estimated according to Kemper and Koch (1966).

f) Correlation analysis

A simple correlation analysis (p = 0.05) was worked out between soil physicochemical properties and spore density of AM fungi in native soil as well as between soil quality parameters in pot cultured soil.

g) Statistical analysis

The data were subjected to statistical analysis by variance (P=0.05) with mean separation by Least significant difference (LSD) as per the methods detailed by the Panse and Sukhatme (1978). The analysis for microbial population count was based on the log and arcsine transformed values.

III. Results

a) Spore count in rhizosphere of Onion

The spore count was found to increase with increase in salinity level in this study while, maximum was at harvest which proved the nature of AM fungi to form spores to survive under stress. The results of the present study showed that the rhizosphere of Onion harboured abundance of spores and was found to increase with each level of stress condition where, the maximum was recorded at L3 (4.5 dSm^{-1}). A steady increase in spore load was observed from the initial stage of observation until harvest invariably in all the treatments where, T5 registered the highest of 121.7 spores 100 gm^{-1} soil respectively and interestingly it was on par with T2, the standard isolate (Fig 1). Present results are consistent with Gupta and Rautaray (2005) who recorded highest spore count in the rhizosphere soil treated with 3 per cent NaCl, inoculated with *Glomus* sp. (68.34 ± 12.01 per 100 g soil) and concluded that the presence of spores in the soil reveals the tolerance of AM fungi (*Glomus* sp.) to NaCl induced stress. The high spore content in soil samples and the intense mycorrhizal colonization of the roots does indicate that AM fungal activity plays a role under such harsh conditions in saline and sodic soils. In general, increases in soil pH, nutrient status and salinity in soil are related to a decrease in AM root colonization or in spore density and suffer adverse effects due to the accumulation of some anions and cations. The decrease in spore density in a particular treatment is attributed to the degree of toleration of that particular strain of AM fungi inoculated (Rao and McNelly, 1999). Similar result was reported by Aliasgharzadeh *et al*. (2001) who evaluated AM diversity in tabriz plains and found the number of AM fungal spores was not correlated significantly with soil salinity.

b) Total microbial population

Though there was a decrease in the microbial population with increase in the salt levels (L2 and L3), the population of fungi dominated the rhizosphere than the other microbes (Table 2). The results registered a maximum of 19.30 x 10^5 cfu bacteria g^{-1} soil in T2, 52.40 x 10^4 cfu fungi g^{-1} soil in T1 and 11.12 x 102 cfu actinomycetes g^{-1} soil in T4. Among the total microbial count, fungi were dominating the rhizosphere in T1 (G. *intraradices*) while bacteria and actinomycetes population were enhanced by T2 (S. *calospora*) inoculation. Influence of microbial populations was reported previously by few workers (Boby and Bagyaraj, 2003). Stimulative effect of AM fungi (*Scutellospora* sp. CAM 3) on microbial population was evidenced by Priya and Kumutha, (2009) where inoculation of G. *mosseae* tremendously increased the population of total bacteria (76.08 x 10^6 cfu), fungi (123.40 x 10^4 cfu) and PGPR (103.70 x 10^6 cfu) in the rhizosphere of mycorrhizal plants at all stages of sampling. In case of salinity not only the soil-borne spores of the AM fungi has ability to withstand adverse soil conditions, but also the extraradical hyphae might protect the host plant from toxic levels of deleterious elements in the growth medium (Li and Christie 2001). It has been shown that extramatrical hyphae of AM fungi exude substances and cause soil and organic fractions to aggregate (Sutton and Sheppard, 1976) in which the microorganisms fluorish.

c) Soil Physical parameters

i. *Soil pH and EC*

The soil pH was observed to remain same throughout the experiment with slight variation with respect to each level of salt (8.27 to 8.10) while there was a noticeable reduction in EC levels in inoculated treatments than the control soil (Fig 2). The decreased electrical conductivity of mycorrhizosphere soil demonstrates that AM fungi have a profound effect on the ionic balance as supported by Rosendahl and Rosendahl (1991). This may be the result of increased absorption and translocation by AM fungal hyphae. The reduction in shoot Na uptake and maintaining electrical conductivity of the soil may be significant in helping mycorrhizal plants to survive in saline conditions. Also studies by Cantrell and Lindermann (2001) proved that AM fungal treatments lowered the soil EC while the control did not express much reduction in EC at the end of experiment.

ii. *Bulk density and Particle density (%)*

In the present study, AM fungal inoculations showed notable decrease in bulk density and particle density. The bulk density of the soil was found to be increased with increase in salt levels. Though much significant difference was not observed between the treatments, AM fungal inoculation lowered the bulk density of soils at all the levels of salt where T1 and T2 showed noticeable decrease compared to other treatments. Treatments T1 and T2 reduced the bulk density upto 1.30, 1.34 and 1.40 per cent at L1, L2 and L3 respectively. In contrast to bulk density of the soil, the particle density was found to be increased with increase in salt levels in all the treatments. Only at L1 and L2, the treatments showed a considerable decrease when compared to the control whereas at L3, significant difference was not observed. Both the treatments T1 and T2 showed 2.4 and 2.50 per cent of particle density at L2 and L3 respectively (Table 3) (Fig 3a).

iii. *Water holding capacity and Porosity (%)*

Water Holding Capacity (WHC) of the soil samples were significantly increased in all the treatments but were found to decrease with increase in salt levels. Among the treatments, T1 showed maximum WHC at all the three levels of salt showing 81.11, 78.86 and 76.86 per cent at L1, L2 and L3 respectively. Also the soil porosity was influenced by the AM fungi to some extent, where the increment in salt levels showed a decrease in pore space in all the treatments. Porosity was maximum in T1 and T2 that showed 53, 51.6 and 50.90 per cent at L1, L2 and L3 respectively (Table 3) (Fig 3b).

Such decreases in bulk and particle density with increase in porosity and water holding capacity at L1 (1.5 dSm-1) than at L2 and L3 (3.0 and 4.5 dSm-1) may be due to that, at high salt levels, the presence of more Na+ ions in the soil cause dispersion of soil aggregates leading to soil compaction leading to hard pan state and therefore a hike in bulk density, particle density and interruption in hydraulic conductivity. Bulk density depends on soil structure and is an indicator of soil compaction, aeration and ease the development of roots. Previous findings confirmed a concurrent decrease in bulk density with an increase in total soil porosity (by 24 per cent) and hydraulic conductivity due to addition of organic materials and a slight increase in soil organic matter due to the AM fungi inoculated treatment (Celik *et al.* 2004; Marinari *et al*. 2000).

d) Soil chemical parameters

i. Organic carbon (%)

The organic carbon content is one of the vital parameter indicating soil fertility which was significantly influenced in the AM inoculated treatments than the control (Table 4). Analysis at 45 DAS showed a maximum of 0.53 per cent in T1 and inclined upto 0.6 per cent at harvest which remarked about 16.7 per cent increase over control followed by T5 that registered about 12.8 per cent increase over control. The content of organic carbon decreased with increments in salt level in all the treatments at both the stages of observation. Inoculation of AM fungal treatments enhance organic matter content in soil by increasing the particulate organic matter and glomalin contents which influence soil structure, water holding capacity (WHC), water, oxygen infiltration rates, carbon (C) storage and soil fertility (Nichols, 2003). But with increase in salt levels the organic carbon content was found to decline in all the treatments in this study. The higher level of Na^+ ions could have dispersed the aggregates in the soil leading to loss in organic carbon content and this may be the cause for this decline at high salts inspite of the AM fungal inoculation.

ii. Microbial biomass carbon

The microbial biomass carbon represents the available carbon pool in the rhizosphere of the plants that may increase with application of bioinoculants. This analysis determined the capacity of the inoculated cultures in maintaining the carbon pool against various levels of stress imposed and the results showed that the rate of microbial biomass carbon was found to be increased at increasing rate with the days of the crop and was maximum at harvest (Table 5). Though the rate of carbon was found to be decreased at high salt levels, the treatments showed an increase over the control at all the levels. At 45 DAS, remarkable increase in microbial biomass carbon was observed in all the treatments which was found to be augmented still at harvest (Fig 4) registering 327.0 mg kg^{-1} (T1). The performance of treatments with a higher per cent of increase over the control even at L3 than at L1 and L2 indicates the mycorrhizal response at higher stress conditions. Sodic soils are high in exchangeable Na^+ and the changes in biomass inputs or organic matter accumulation will alter soil organic carbon levels in soil. Although soil microbial biomass only comprises 1-5% of SOC (Sparling, 1992) it is critical in organic matter decomposition and can provide an early indicator of SOM dynamics as a whole due to its faster turnover time. Addition of organic material to the scalded soils showed increase in SMB levels and respiration rates than in non degraded soils (Wong *et al*. 2010).

iii. Total Glomalin (TG)

Accumulation of glomalin in soil requires a minimum of 8 to 10 weeks and therefore the soil samples were analysed 8 weeks after sowing (at 45 DAS and at harvest). The total extractable glomalin after purification was estimated in the salt imposed soils. The content of glomalin was found to be decreased with increase in levels of salt and maximum accumulation was noticed at harvest than at 45 DAS where the highest was 153 μg glomalin g-1 soil in T1 at L1 (1.5 dSm-1) at harvest. Purified protein was taken for the SDS PAGE analysis which weighed protein bands of 55 kDa indicating the presence of glomalin in all the treatments except the control (Fig 5, 6). With increase in salt levels, the rate of glomalin accumulation decreased at L3 and this is in accordance with experiments by Kohler et al. (2010). They concluded that, Glomalin related soil proteins decreased at high salt stress (66 μg/ g of soil) than at low salt (77 μg/ g of soil) in soils inoculated with *Glomus mosseae*. The higher concentrations of glomalin in the soil aggregates under saline stress may be related to the occurrence of the highest levels of sodium in the soil and the efficiency of glomalin to sequester different toxic elements (Gonzalez-Chavez et al. 2004). The increase in glomalin concentrations in this study at harvest, can be attributed to, multiplication of AM fungi, through high sporulation especially to encounter the stress condition and due to formation of aggregates in soil within which the protein is glued. Since glomalin represents an investment of C by AM fungi, it makes sense that glomalin production increases as C availability rises (Treseder and Turner, 2007).

iv. Aggregate stability percentage

Aggregation is a soil quality factor that positively affects water infiltration rates, resistance to erosion and nutrient cycling. The fraction or type of carbon compound influences the persistence and water-stability of aggregates. In this study, formation of aggregates in the soil was very much influenced by the

AM fungal inoculation and the stability of aggregates was maximum at harvest than at 45 DAS showing significant difference with that of control. Aggregate stability percentage was affected by increase in salt levels and the lowest aggregation percentage was observed at L3. At 45 DAS, T1 and T2 marked the highest of 92.3 and 87.4 per cent increase over control respectively and the trend increased at harvest showing maximum of 129.4 and 130.7 per cent increase over control in T1 and T2 (Table 6). Bethlenfalvay et al. (1999) reported that water-stable soil aggregates were positively correlated with root and mycorrhiza infection. Wright and Upadhyaya (1998) showed that there is a strong correlation between aggregate stability and glomalin, a glycoprotein produced by hyphae of arbuscular mycorrhizal fungi. Mycorrhizal fungi were stated to be a powerful component in soil environments and soil sustainability especially for soil quality (Ortas, 2002).

Mycorrhizal inoculations promoted more soil aggregation to a maximum of 130.7 per cent increase over control in T2 at harvest than at 45 DAS in this study. Hamel *et al*. (1997) found a positive relationship between two species of *Glomus* (G. *caledonium* and G. *macrocarpum*) and the proportion of water stable soil aggregates in the 0.5–2 mm diameter range. With increase in salt levels, aggregate stability was found to decrease (55 53 and 51 per cent at L1, L2 and L3 respectively) and these results were in accordance with Kohler et al. (2010) where, decreased aggregate stability and glomalin-related soil protein (GRSP) concentration were recorded with increasing saline stress in soils inoculated with G. *mosseae*. Also these findings suggested that the use of AM fungi for alleviating salinity stress in lettuce plants would be possible to some extent in bringing out soil structural stability.

v. *Available micronutrient contents*

The soil micronutrient contents were found to be decreased with increase in salt levels as well as with stages of plant growth and the nutrient availability were statistically non significant under the interaction between the treatments and salt levels. Among the three salt levels, soils with L1 (1.5 dSm-1) accumulated higher micronutrients both at 45 DAS and at harvest. Among the micronutrients analysed, iron was higher in soils than others. In L1, highest of 6.17 ppm iron was observed in T2 that was on par with T1 and (Fig 7).

e) *Correlation study between soil aggregation and soil physico-chemical parameters*

A simple correlation analysis was worked out between accumulation of glomalin protein and physicochemical parameters in soil. The analysis indicated that a significant positive correlation existed between glomalin protein with soil organic carbon and aggregate stability with high 'r' value (0.979 and 0.942 respectively) (Fig 8). Hamel *et al*. (1997) reported that, a positive correlation existed between AM fungal inoculations with (G. *intraradices* and G. *versiforme*) and abundance of water stable soil aggregates in the 0.5–2 mm diameter range in leek plants (*Allium porum*). In this study, Iron content in soil correlated highly (r =0.924) with glomalin content and this is line with Nichols and Wright (2005) proved that the changes in Fe percentage were significantly correlated with the changes in glomalin weight and carbon per cent. The glomalin, humin, humic acid, fulvic acid and total carbon weights were related to iron concentration in the aggregates which indicated that these organic matter fractions are stabilized within organo-mineral complexes formed by iron bridging organic matter to clay particles. Another correlation analysis between soil aggregate stability with water holding capacity and porosity also showed a more positive correlation (0.795 and 0.843 respectively) while a negative correlation existed between aggregate stability with bulk density (-0.987) and particle density (-0.963) at 5 % level of significance (Table 7, Fig 8). Celik *et al*. (2004) confirmed a concurrent decrease in bulk density with an increase in total soil porosity (by 24 per cent) due to slight increase in soil organic matter due to the AM fungus inoculated treatment. This proved the effect of soil physical parameters by mycorrhizal inoculations due to the possible stimulating effect on soil aggregation. Marinari *et al*. (2000) also found that bulk density was lowered and total soil porosity increased at the presence of organic matter. Water retention capacity of soils with high porosity was higher than the soils with low porosity. Aggelides and Londra (2000) determined that porosity and water retention capacity of loamy and clay soils increased with application of organic amendments which in turn enhance soil aggregation.

IV. Conclusion

These findings support the correlations that exist between soil organic carbon, bulk density and porosity. The saturated hydraulic conductivity is generally related to soil porosity especially macroporosity since it increases significantly with an increase in porosity. Previous works have also determined that porosity and water retention capacity of loamy and clay soils increased with application of organic amendments. Also the hike in glomalin contents (the compound responsible for sequestering for carbon) in the AM fungal treatments, especially at harvest stage of the crop puts forth to increase in organic carbon contents. The fractions of the soil organic matter is a key attribute of soil quality that impacts soil aggregation and accordingly increases water infiltration and these effects of soil physical parameters by mycorrhizal inoculations overcomes the

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hard pan formation and enhances root penetration and proliferation. Thus the effect of AM fungal inoculation in maintenance of soil properties through the influence on glomalin content, soil organic matter content and therefore soil aggregation at various salinity levels in the rhizosphere of Onion is enlightened.

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Table 2 : Effect of AM fungal isolates on microbial count in Onion against various levels of salinity

Treatments	Microbial count (cfu g^{-1} ODS) at 45 DAS														
	Bacteria x 10^5					Fungi x 10^4					Actinomycetes x 10^2				
	L1	L2	L3	Mean	Per cent increase over control	L1	L2	L3	Mean	Per cent increase over control	L1	L2	L3	Mean	Per cent increase over control
G. intraradices	19.17	12.10	10.44	13.90	60.51	52.40	45.17	38.40	45.32	178.89	9.23	6.77	3.86	8.00	422.88
S. calospora	19.30	13.34	10.40	14.35	65.70	39.30	28.00	23.45	30.25	86.15	10.22	9.32	6.82	8.80	474.29
TRY1	11.50	12.82	9.82	11.38	31.41	20.17	36.25	14.48	23.63	45.42	9.61	5.72	4.70	6.68	336.38
TRY 2	11.00	10.95	9.94	10.63	22.75	19.01	24.50	35.90	26.47	62.89	11.12	5.01	3.60	6.58	329.85
TRY 3	15.20	10.34	8.51	11.35	31.06	45.33	41.33	34.40	40.35	148.31	7.21	5.60	3.10	5.30	246.62
TFS 1	12.05	9.34	8.95	10.11	16.74	23.30	33.27	11.33	22.63	39.26	7.20	5.31	3.90	5.47	257.52
Control	10.50	9.12	6.37	8.66	-	10.22	23.33	15.20	16.25	-	2.00	1.48	1.12	1.53	-
Mean	14.10	11.14	9.20	11.48		29.96	33.12	24.74	29.27		8.08	5.60	3.87	5.85	
	SEd		CD (0.05)			SEd		CD (0.05)			SEd		CD (0.05)		
T	0.16		0.33			0.62		1.26			0.15		0.30		
L	0.10		0.21			0.41		0.83			0.09		0.19		
T x L	0.28		0.57			1.08		2.19			0.26		0.52		

L1 – 1.5 dSm^{-1}; L2 - 3.0 dSm^{-1}; L3 – 4.5 dSm^{-1}; DAS – Days after sowing;
Values represent mean of three replicates;
Value in paranthesis indicate per cent increase over control

G. intraradices - *Glomus intraradices*
S. calospora - *Scutellospora calospora*
TRY 1- *Acaulospora* sp
TRY 2- *Scutellospora* sp.
TRY 3- *Glomus mosseae*
TFS 1- *Glomus aggregatum*

Table 3 : Effect of AM fungal isolates on percentage of bulk density, particle density, water holding capacity and porosity in rhizosphere of Onion against various levels of salinity

S.No	Treatments	Bulk density (%)			Mean	Particle density (%)			Mean	Water holding capacity (%)			Mean	Porosity (%)			Mean
		L1	L2	L3		L1	L2	L3		L1	L2	L3		L1	L2	L3	
1.	*G. intraradices*	1.30	1.34	1.40	1.34 (-7.4)	2.41	2.50	2.65	2.52 (-3.1)	81.11	78.86	76.86	78.94 (19.7)	53.00	51.60	50.90	51.83 (8.1)
2.	*S. calospora*	1.30	1.34	1.40	1.35 (-7.1)	2.42	2.50	2.65	2.52 (-2.9)	80.90	78.01	76.13	78.35 (18.8)	52.80	51.40	50.00	51.40 (7.2)
3.	TRY 1	1.32	1.35	1.42	1.36 (-6.0)	2.46	2.54	2.66	2.55 (-1.8)	76.86	76.02	72.13	75.00 (13.7)	50.00	49.60	47.40	49.00 (2.2)
4.	TRY 2	1.33	1.36	1.42	1.37 (-5.5)	2.44	2.53	2.65	2.54 (-2.3)	79.24	75.22	73.30	75.92 (15.1)	50.10	49.10	48.00	49.07 (2.4)
5.	TRY 3	1.32	1.36	1.45	1.38 (-5.1)	2.44	2.52	2.65	2.54 (-2.4)	77.75	78.00	75.00	76.92 (16.6)	50.80	49.70	48.10	49.53 (3.3)
6.	TFS 1	1.33	1.36	1.45	1.38 (-4.8)	2.46	2.53	2.66	2.55 (-1.9)	70.48	69.01	68.46	69.32 (5.1)	50.80	49.70	48.10	49.53 (3.3)
7.	Control	1.40	1.43	1.53	1.45	2.53	2.60	2.67	2.60	68.21	65.43	64.22	65.95	49.30	47.50	47.00	47.93
	Mean	1.33	1.36	1.44	1.38	2.45	2.53	2.66	2.55	76.36	74.36	72.30	74.34	50.97	49.80	48.50	49.76
		SEd		CD (0.05)		SEd		CD (0.05)		SEd		CD (0.05)		SEd		CD (0.05)	
	T	0.003		0.006		0.003		0.007		0.25		0.52		0.087		0.177	
	L	0.002		0.004		0.002		0.005		0.16		0.34		0.057		0.116	
	T x L	0.005		0.011		0.006		0.013		0.44		0.90		0.152		0.307	

Table 4 : Effect of AM fungal isolates on organic carbon content in Onion rhizosphere against various levels of salinity

S.No	Treatments	Organic carbon content (%)									
		45 DAS			Mean	Per cent increase over control	At harvest			Mean	Per cent increase over control
		L1	L2	L3			L1	L2	L3		
1.	*G. intraradices*	0.56	0.53	0.50	0.53	8.2	0.63	0.61	0.58	0.61	16.7
2.	*S. calospora* sp.	0.55	0.52	0.50	0.52	6.8	0.62	0.61	0.58	0.60	16.0
3.	TRY 1	0.52	0.51	0.48	0.50	2.7	0.60	0.58	0.55	0.58	10.9
4.	TRY 2	0.52	0.51	0.48	0.50	2.7	0.61	0.58	0.55	0.58	11.5
5.	TRY 3	0.55	0.52	0.48	0.52	5.4	0.61	0.60	0.55	0.59	12.8
6.	TFS 1	0.55	0.50	0.48	0.51	4.1	0.60	0.57	0.55	0.57	10.3
7.	Control	0.52	0.48	0.47	0.49	-	0.54	0.53	0.50	0.52	-
	Mean	0.54	0.51	0.48	0.51		0.60	0.58	0.55	0.58	
		SEd		CD (0.05)			SEd		CD (0.05)		
	T	0.002		0.004			0.002		0.005		
	L	0.001		0.002			0.001		0.003		
	T x L	0.003		0.007			0.004		0.008		

L1 – 1.5 dSm^{-1}; L2 - 3.0 dSm^{-1}; L3 – 4.5 dSm^{-1}; DAS – Days after sowing;
Values represent mean of three replicates;
Value in paranthesis indicate per cent increase over control

G. intraradices - *Glomus intraradices* *S. calospora* - *Scutellospora calospora*
TRY 1- *Acaulospora* sp TRY 3- *Glomus mosseae*
TRY 2- *Scutellospora* sp. TFS 1- *Glomus aggregatum*

Table 5 : Effect of AM fungal isolates on microbial biomass carbon in Onion rhizosphere against various levels of salinity

S.No	Treatments	Microbial biomass carbon (mg kg $^{-1}$)												Per cent increase over control
		30 DAS			Mean	45 DAS			Mean	At harvest			Mean	
		L1	L2	L3		L1	L2	L3		L1	L2	L3		
1.	*G. intraradices*	183.0 (51.2)	152.0 (32.1)	136.0 (25.9)	157.0	294.0 (50.0)	280.0 (71.7)	269.0 (99.2)	281.0	345.0 (35.8)	325.0 (27.9)	311.0 (42.0)	327.0	43.2
2.	*S. calospora*	176.0 (45.4)	155.0 (34.7)	135.0 (25.0)	155.3	288.0 (46.9)	278.0 (70.5)	244.0 (80.7)	270.0	330.0 (144.4)	317.0 (134.8)	305.0 (39.2)	317.3	39.0
3.	TRY 1	150.0	138.0	125.0	137.7	262.0	248.0	228.0	246.0	289.0	265.0	244.0	266.0	16.5
4.	TRY 2	159.0	138.0	123.0	140.0	269.0 (37.2)	251.0 (54.0)	236.0 (74.8)	252.0	325.0 (140.7)	295.0 (118.5)	268.0 (22.3)	296.0	29.7
5.	TRY 3	162.0 (33.8)	148.0 (28.7)	138.0 (13.9)	149.3	244.0	233.0	221.0	232.7	298.0	272.0	253.0	274.3	20.2
6.	TFS 1	135.0	119.0	111.0	121.7	237.0	218.0	200.0	218.3	277.0	258.0	238.0	257.7	12.9
7.	Control	121.0	115.0	108.0	114.7	196.0	163.0	135.0	164.7	254.0	212.0	219.0	228.3	-
	Mean	155.1	137.9	125.1	139.3	255.7	238.7	219.0	237.8	302.6	277.7	262.6	280.9	
		SEd		CD (0.05)		SEd		CD (0.05)		SEd		CD (0.05)		
	T	1.06		2.14		2.07		4.19		1.94		3.92		
	L	0.69		1.40		1.35		2.744		1.27		2.57		
	T x L	1.84		3.71		3.59		7.27		3.36		6.80		

L1 – 1.5 dSm^{-1}; L2 - 3.0 dSm^{-1}; L3 – 4.5 dSm^{-1}; DAS – Days after sowing;
Values represent mean of three replicates;
Value in paranthesis indicate per cent increase over control

G. intraradices - *Glomus intraradices* *S. calospora* - *Scutellospora calospora*
TRY 1- *Acaulospora* sp TRY 3- *Glomus mosseae*
TRY 2- *Scutellospora* sp. TFS 1- *Glomus aggregatum*

Table 6 : Effect of AM fungal isolates on percentage of aggregate stability in Onion rhizosphere against various levels of salinity

S.No	Treatments	Aggregate stability (%)									
		45 DAS			Mean	Per cent increase over control	At harvest			Mean	Per cent increase over control
		L1	L2	L3			L1	L2	L3		
1.	*G. intraradices*	48.5 (88.7)	43.2 (24.1)	42.7 (112.4)	44.80	92.3	55.2 (116.5)	53.0 (122.7)	50.8 (154.0)	53.00	129.4
2.	*S. calospora*	46.2 (80.0)	42.8 (78.0)	42.0 (109.0)	43.67	87.4	55.0 (115.7)	53.8 (126.0)	51.1 (155.5)	53.30	130.7
3.	TRY 1	43.2	40.3	38.2	40.57	74.1	45.6	41.6	40.9	42.70	84.8
4.	TRY 2	42.8	40.6	38.9	40.77	75.0	43.7	42.8	41.5 (104.5)	42.67	84.7
5.	TRY 3	45.4 (76.6)	41.6 (72.6)	40.5 (101.5)	42.50	82.4	47.7 (87.06)	43.8 (84.0)	40.9	44.13	91.1
6.	TFS 1	42.7	40.0	38.7	40.47	73.7	47.0	43.5	40.1	43.53	88.5
7.	Control	25.7	24.1	20.1	23.30	-	25.5	23.8	20.0	23.10	-
	Mean	42.07	38.94	37.30	39.43		45.67	43.19	40.76	43.20	
		SEd		CD (0.05)			SEd		CD (0.05)		
	T	0.37		0.75			0.50		1.02		
	L	0.24		0.49			0.33		0.66		
	T x L	0.65		1.31			0.87		1.77		

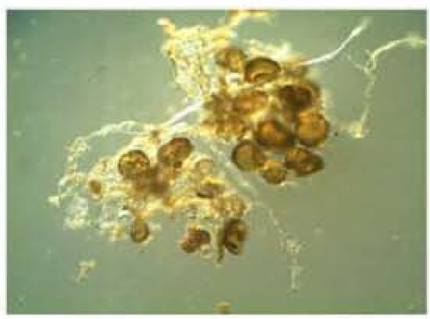
L1 – 1.5 dSm^{-1}; L2 - 3.0 dSm^{-1}; L3 – 4.5 dSm^{-1}; DAS – Days after sowing;
Values represent mean of three replicates;
Value in paranthesis indicate per cent increase over control

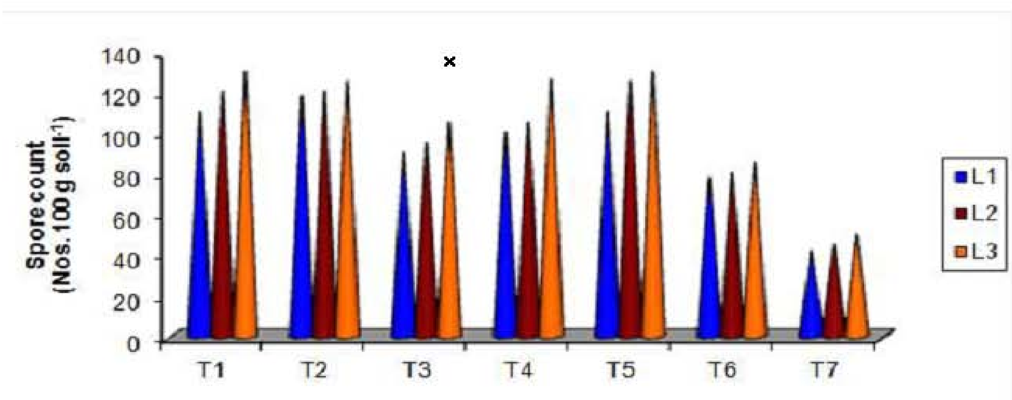
G. intraradices - *Glomus intraradices* *S. calospora* - *Scutellospora calospora*
TRY 1- *Acaulospora* sp TRY 3- *Glomus mosseae*
TRY 2- *Scutellospora* sp. TFS 1- *Glomus aggregatum*

Table 7 : Correlation analysis of Glomalin with soil parameters at L1 (1.5 dSm-1) in post harvest soil of Onion rhizosphere

S. No	Relationship between		Correlation coefficient (r)	Level of significance
	X	Y		
1.	Glomalin	Iron content	0.924	0.05
2.	Glomalin	Organic carbon	0.979	0.05
3.	Glomalin	Aggregate stability	0.942	0.05
4.	Aggregate stability	Water holding capacity	0.795	0.05
5.	Aggregate stability	Porosity	0.843	0.05
6.	Aggregate stability	Bulk density	-0.987	0.05
7.	Aggregate stability	Particle density	-0.963	0.05

Figure 1. Effect of AM fungal isolates on spore count in the rhizosphere of Onion against various levels of salinity at harvest





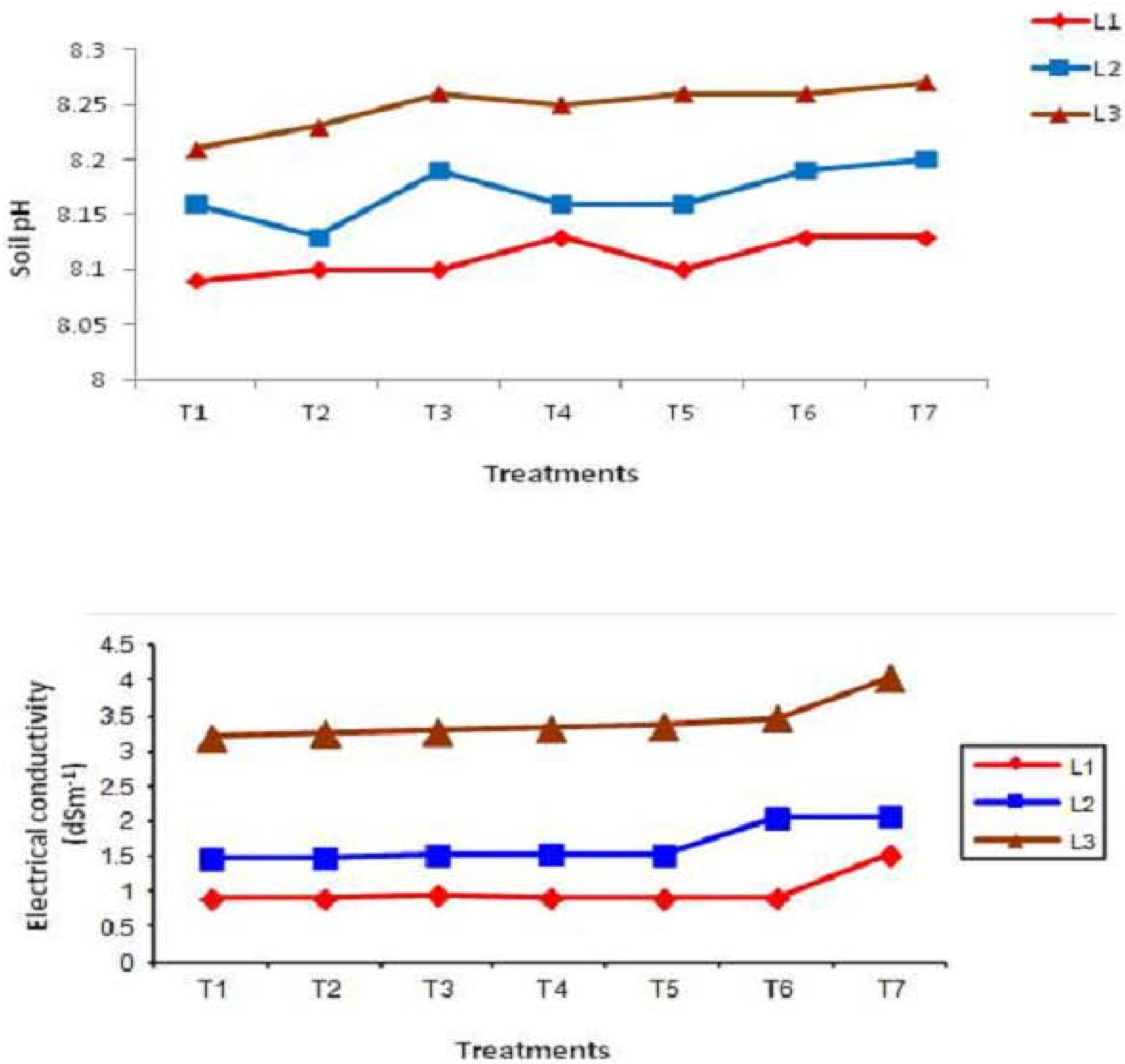
Treatments

T1 - *Glomus intraradices*
T2 - *Scutellospora calospora*
T3 - TRY 1 (*Acaulospora* sp.)
T4 - TRY 2 (*Scutellospora* sp.)
T5 - TRY 3 (*Glomus mosseae*)
T6 – TFS 1 (*Glomus aggregatum*)
T7 - Control

Levels

L1 -1.5 dSm^{-1}
L2 -3.0 dSm^{-1}
L 3 - 4.5 dSm^{-1}

Figure 2. Effect of AM fungal isolates on soil pH and EC in rhizosphere of Onion against various levels of salinity



Treatments

T1 - *Glomus intraradices*
T2 - *Scutellospora calospora*
T3 - TRY 1 (*Acaulospora* sp.)
T4 - TRY 2 (*Scutellospora* sp.)
T5 - TRY 3 (*Glomus mosseae*)
T6 – TFS 1 (*Glomus aggregatum*)
T7 - Control

Levels

L1 - 1.5 dSm^{-1}
L2 - 3.0 dSm^{-1}
L 3 - 4.5 dSm^{-1}

Figure 3a. Effect of AM fungal isolates on bulk density and particle density in Onion rhizosphere at 1.5 dSm^{-1}

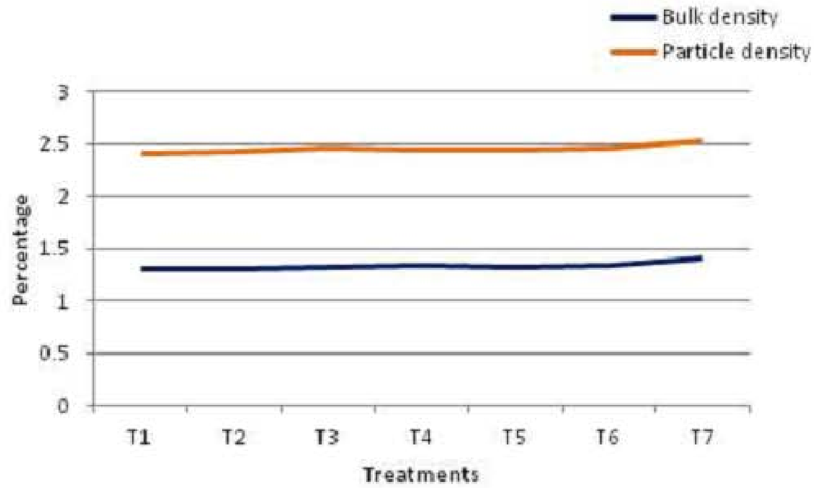
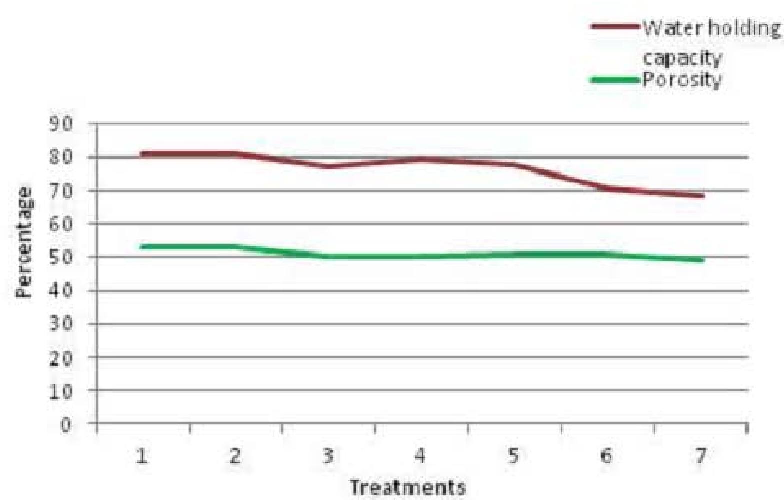


Figure 3b. Effect of AM fungal isolates on water holding capacity and porosity in Onion rhizosphere at 1.5 dSm^{-1}



Treatments

T1 - *Glomus intraradices*

T2 - *Scutellospora calospora*

T3 - TRY 1 (*Acaulospora* sp.)

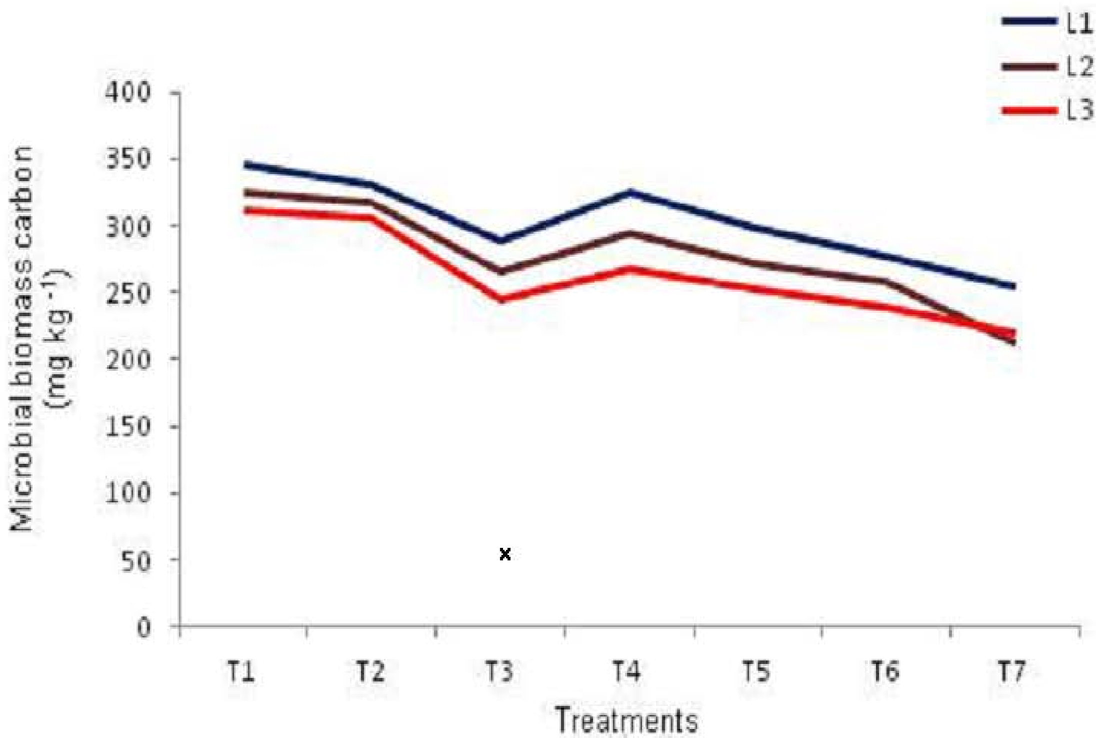
T4 - TRY 2 (*Scutellospora* sp.)

T5 - TRY 3 (*Glomus mosseae*)

T6 – TFS 1 (*Glomus aggregatum*

T7 - Control

Figure 4. Effect of AM fungal isolates on microbial biomass carbon In the rhizosphere of Onion at harvest



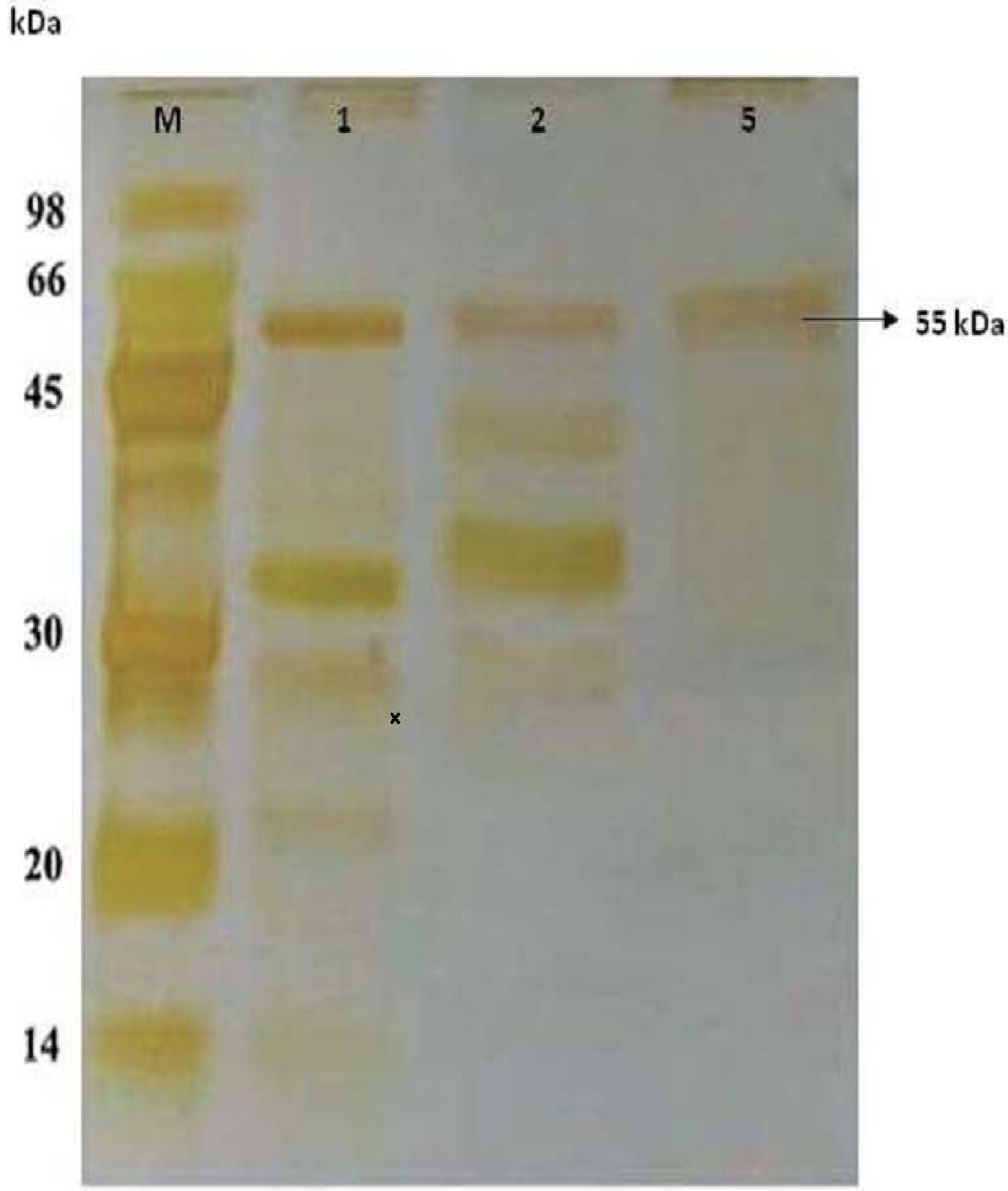
Treatments

T1 - *Glomus intraradices*
T2 - *Scutellospora calospora*
T3 - TRY 1 (*Acaulospora* sp.)
T4 - TRY 2 (*Scutellospora* sp.)
T5 - TRY 3 (*Glomus mosseae*)
T6 – TFS 1 (*Glomus aggregatum*)
T7 - Control

Levels

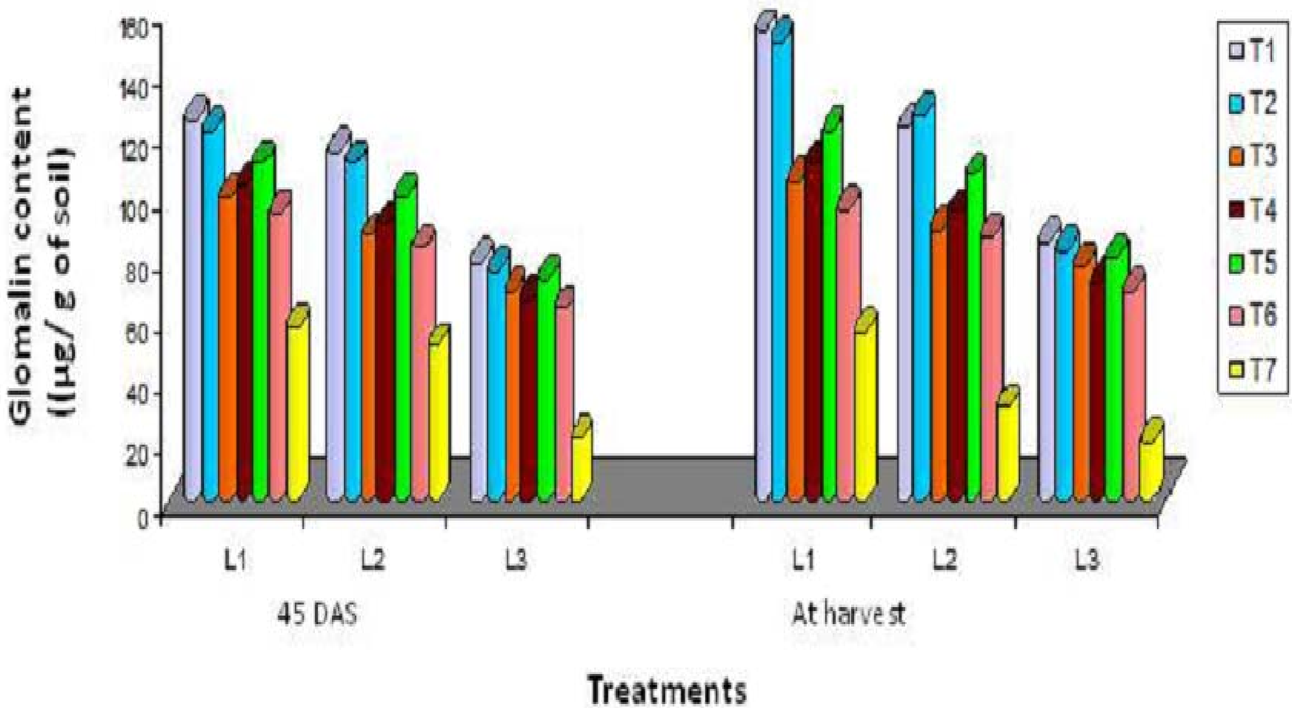
L1 - 1.5 dSm^{-1}
L2 - 3.0 dSm^{-1}
L 3 - 4.5 dSm^{-1}

Figure 5. SDS PAGE profile of total glomalin in rhizosphere of onion grown with low level of salinity (L1- 1.5 dSm^{-1})



Lane 1 – T1 (*Glomus intraradices*)
Lane 2 – T2 (*Scutellospora calospora*)
Lane 5 – T5 (TRY 3)

Figure 6. Effect of AM fungal isolates on Glomalin content in the rhizosphere of Onion at various levels of salinity



Treatments

T1 - *Glomus intraradices*
T2 - *Scutellospora calospora*
T3 - TRY 1 (*Acaulospora* sp.)
T4 - TRY 2 (*Scutellospora* sp.)
T5 - TRY 3 (*Glomus mosseae*)
T6 – TFS 1 (*Glomus aggregatum*)
T7 - Control

Levels

L1 - 1.5 dSm^{-1}
L2 - 3.0 dSm^{-1}
L 3 - 4.5 dSm^{-1}

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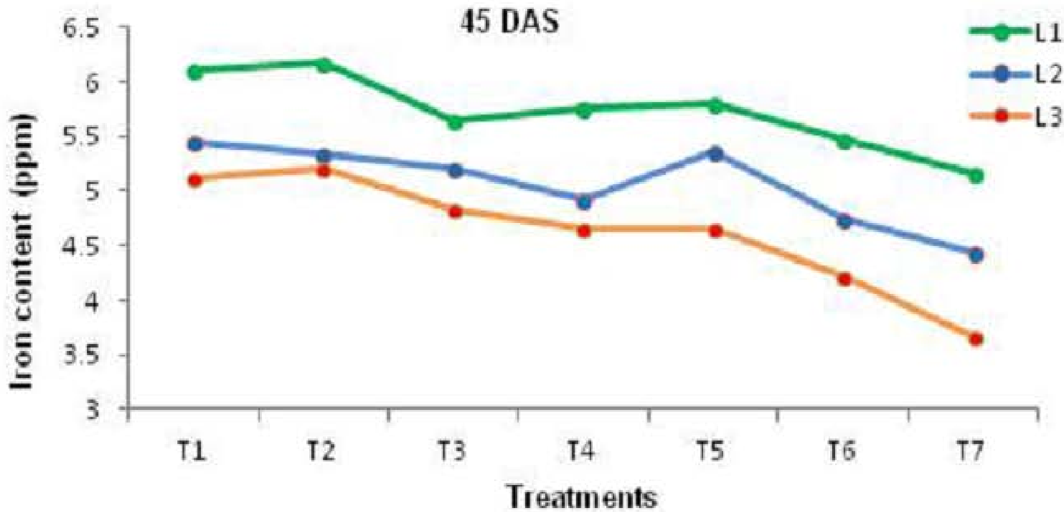
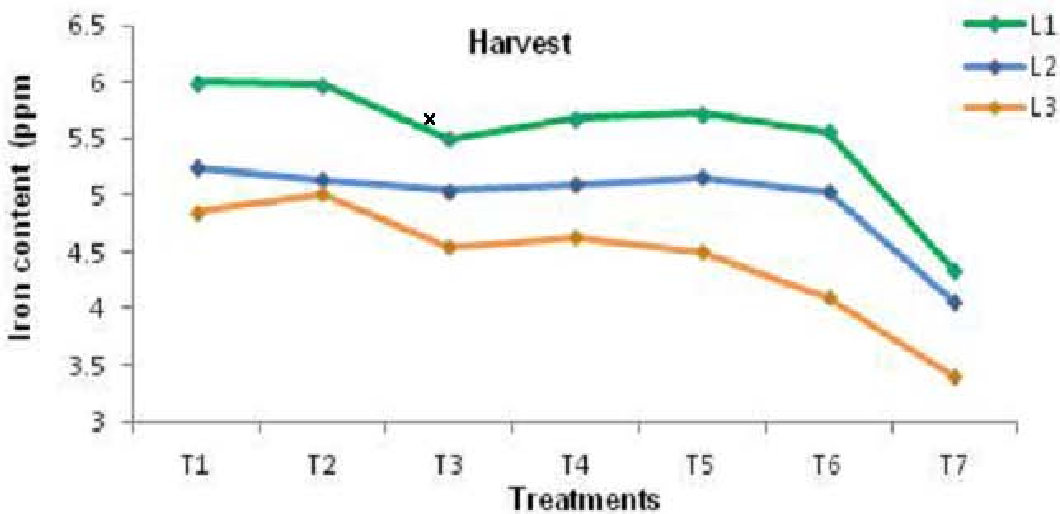
Figure 7. Effect of AM fungal isolates on iron availability in rhizosphere soil of Onion against various levels of salinity





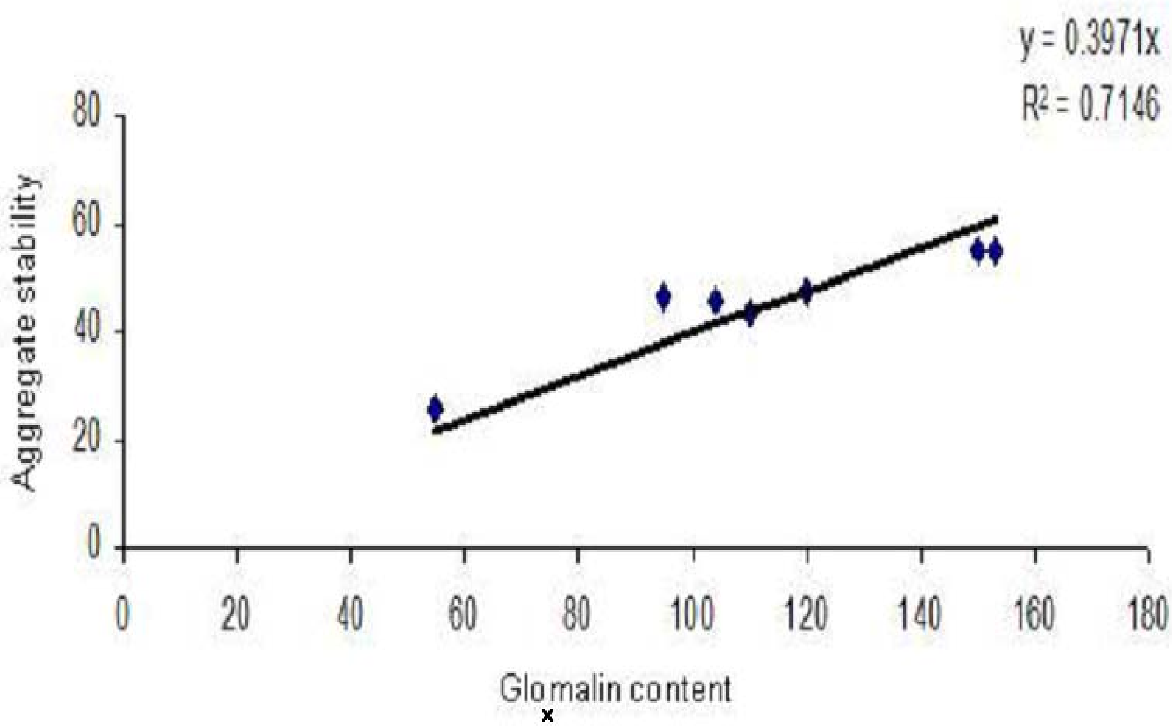
Treatments

T1 - *Glomus intraradices*
T2 - *Scutellospora calospora*
T3 - TRY 1 (*Acaulospora* sp.)
T4 - TRY 2 (*Scutellospora* sp.)
T5 - TRY 3 (*Glomus mosseae*)
T6 – TFS 1 (*Glomus aggregatum*)
T7 - Control

Levels

L1 - 1.5 dSm^{-1}
L2 - 3.0 dSm^{-1}
L3 - 4.5 dSm^{-1}

Figure 8. Correlation analysis between glomalin content and aggregate stability at L1 (1.5 dSm⁻¹)



Treatments

T1 - *Glomus intraradices*
T2 - *Scutellospora calospora*
T3 - TRY 1 (*Acaulospora* sp.)
T4 - TRY 2 (*Scutellospora* sp.)
T5 - TRY 3 (*Glomus mosseae*)
T6 – TFS 1 (*Glomus aggregatum*
T7 - Control

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Role of Hydrogen Cyanide Secondary Metabolite of Plant Growth Promoting Rhizobacteria as Biopesticides of Weeds

By Adam Kamei, Ashim Kumar Dolai & Apou Kamei

Menace of Weeds in Crop Production- Weeds are different from the other pests that pose problems in crop production because the presence of weeds is relatively constant, while outbreaks of insects and disease pathogens are sporadic (Gianessi and Sankula, 2003). 1,800 weeds species cause serious economic losses in crop production, and about 300 species plague cultivated crops throughout the world (Ware and Whitacre, 2004). Weeds are the scarce and silent robbers of plant nutrients, soil moisture, solar energy and also occupy the space which would otherwise be available to the main crop; harbour insect-pests and disease causing organisms; exert adverse allelopathic effects; reduce quality of farm produce and increase cost of production.

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Role of Hydrogen Cyanide Secondary Metabolite of Plant Growth Promoting Rhizobacteria as Biopesticides of Weeds

Adam Kamei [α], Ashim Kumar Dolai [σ] & Apou Kamei [ρ]

I. Menace of Weeds in Crop Production

Weeds are different from the other pests that pose problems in crop production because the presence of weeds is relatively constant, while outbreaks of insects and disease pathogens are sporadic (Gianessi and Sankula, 2003). 1,800 weeds species cause serious economic losses in crop production, and about 300 species plague cultivated crops throughout the world (Ware and Whitacre, 2004). Weeds are the scarce and silent robbers of plant nutrients, soil moisture, solar energy and also occupy the space which would otherwise be available to the main crop; harbour insect-pests and disease causing organisms; exert adverse allelopathic effects; reduce quality of farm produce and increase cost of production.

Yield losses due to weeds in some important crops

Crop	Yield loss range (%)	Crop	Yield loss range (%)
Rice	9.1 – 51.4	Sugarcane	14.1 – 71.7
Wheat	6.3 – 34.8	Linseed	30.9 – 39.1
Maize	29.5 – 74.0	Cotton	20.7 – 61.0
Millets	6.2 – 81.9	Carrot	70.2 – 78.0
Groundnut	29.7 – 32.9	Peas	25.3 – 35.5

Among the pests weeds account for 45 % reduction in yield while the insects 30%, diseases 20% and other pests 5% (Rao, 2000). There are several methods for controlling weeds such as cultural method achieved less efficient, manual weeding is very expensive and it may be difficult to find labour. Additionally, it is strenuous and physically demanding and can cause overload injuries (Hansson et al., 1992; Chatizwa, 1997) and mechanical method such heat treatment consumed more energy which leads to input-cost. Soil solarization is a hydrothermal process, which brings about thermal and other physical, chemical and biological changes in the moist soil during and even after mulching (Stapleton and DeVay, 1986). Dilday et al. (1998) has been reported weed emergence by used of allelopathy approach. Modern weed control, chemical method herbicides are gaining popularity among the farmers. The use of agrochemicals is negatively perceived by consumers and supermarket chains. Use of heavy doses of herbicides creates the problem of resistance development in weed. Another problem is continuous use of one herbicide can change the weed community. The use of microbes to control weeds menace, which is a form of biological

weeds menace, which is a form of biological control, is an environment-friendly approach as sustainable tools. The microbe is a natural enemy of the pathogen, and if it produces secondary metabolites, it does so only locally, on or near the plant surface, i.e., the site where it should act to target. In contrast, the majority of molecules of agrochemicals do not reach the plant at all. Moreover, the molecules of biological origin are biodegradable compared with many agrochemicals that are designed to resist degradation by microbes. The above mentioned results, as well as the fact that registration of antibiotic-producing products is discouraged because of possible cross-resistance with antibiotics applied for human and animal use, suggest that biocontrol strains based on mechanisms other than antibiosis might have a better future for surviving the registration procedure and therefore becoming a product. PGPR have gained worldwide importance and considered as important tools in sustainable agriculture due to their plant growth promotional ability as well as bio-control potential because they can reduce harm caused by pathogens and therefore can be potentially utilized as biopesticides.

II. Concept of Biological Control

The terms "biological control" and its abbreviated synonym "biocontrol" have been used in different fields of biology, most notably entomology and plant pathology. In entomology, it has been used to

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describe the use of live predatory insects, entomopathogenic nematodes, or microbial pathogens to suppress populations of different pest insects. In plant pathology, the term applies to the use of microbial antagonists to suppress diseases as well as the use of host-specific pathogens to control weed populations. In both fields, the organism that suppresses the pest or pathogen is referred to as the biological control agent (BCA).

III. Plant Growth Promoting Rhizobacteria as Biological Control Agent (BCA)

The use of PGPR offers an attractive way to replace chemical fertilizer, pesticides, and supplements; most of the isolates result in a significant increase in biological control agents. PGPR is gaining momemtum in the weed control in crop fields. Antibiotics identified in antagonistic gram negative biocontrol bacteria include the classical compounds HCN (Haas D, Keel C. 2003) which is a volatile compound suppressor of weeds. It is noted that some rhizobacteria are also active against weeds (Flores-Fargas RD and O'Hara GW. 2006) and insects (P´echy-Tarr M, *et al.* 2008), *Meloydogyne incognita* (Siddiqui A, Haas D, Heeb S. 2005), Carabid beetles such as *Harpalus pensylvanicus* are common in many crop fields and can eat and destroy large numbers of weed seeds. Natural enemies of weeds are often present naturally in crop fields.

IV. Hydrogen Cyanide a Promising Secondary Metabolites of Plant Growth Promoting Rhizobacteria as Biocontrol Tools

One group of microorganisms which acts as biocontrol agents against weeds include the Deleterious Rhizobacteria (DRB) that can colonize plant root surfaces (Suslow TV and Schroth MN, 1982). Many Deleterious Rhizobacteria Bacteria are plant specific (Schippers B, *et al*, 1987). Cyanide is a dreaded chemical produced by them as it has toxic properties. Although cyanide acts as a general metabolic inhibitor, it is synthesized, excreted and metabolized by hundreds of organisms, including bacteria, algae, fungi, plants, and insects, as a mean to avoid predation or competition. The host plants are generally not negatively affected by inoculation with cyanide producing bacterial strains and host-specific rhizobacteria can act as biological weed-control agents (Zeller SL *et al*, 2007). A secondary metabolite produced commonly by rhizosphere pseudomonads is Hydrogen Cyanide (HCN), a gas known to negatively affect root metabolism and root growth (Schippers B, *et al,* 1990) and is a potential and environmentally compatible mechanism for biological control of weeds (Heydari S, *et al*, 2008). The HCN production is found to be a common trait of *Pseudomonas* (88.89%) and Bacillus (50%) in the rhizospheric soil and plant root nodules (Ahmad F, *et al*, 2009) and is a serious environmental pollutant and a biocontrol metabolite in *Pseudomonas* species. Advancement of HCN potential in weed control, depth investigation (Castric PA, 1977) was carried out to enhance the HCN activity. But role of glycine is documented in biocontrol. It was previously not known if glycine was a carbon precursor for HCN in *Pseudomonas aeruginosa*. Castric presented evidence that glycine is an HCN precursor for P. *aeruginosa*, but that this process differs significantly from cyanogenesis in other bacteria because: (i) other amino acids besides glycine stimulate HCN production; and (ii) both carbons of glycine are used as sources of cyanide carbon. The level of HCN produced in root-free soil by P. *putida* and A. *delafieldii* generally increased with higher amounts of supplemental glycine, with P. *putida* typically generating more HCN (8–38 μM) at a given glycine level (Owen A, Zdor R, 2001). The sorghum seedlings [*Sorghum bicolor* (L) Moench] of different genotypes differ in associations with soil microorganisms and differentially affect the number of FLPs in cropping systems (Funnell-Harris DL, 2008). Some of the recent studies have indicated that and some of the Pseudomonas spp. metabolites such as HCN may enhance plant establishment. Wani *et al.* (Wani PA, 2007) tested the rhizosphere isolates for HCN producing ability *in vitro* to find that most of the isolates produced HCN and helped in the plant growth. The isolates from the rhizospheric soil of chickpea also exhibits more than two or three PGPR traits including HCN production, which promotes plant growth directly or indirectly or synergistically. The rhizosphere competent *Mesorhizobiumloti* MP6 produces hydrocyanic acid (HCN) under normal growth conditions and enhances the growth of Indian mustard (*Brassica campestris*) (Chandra S, 2007). Bacterial isolates belonging to genera *Bacillus* and *Pseudomonas* isolated from rhizospheric soils of mustard produces HCN and application of herbicides (quizalafop-p-ethyl & clodinafop) do not have any significant change in HCN production by these isolates (Munees A and Mohammad SK, 2009]. The entomopathogenic bacterium *Pseudomonas entomophila* produces HCN which is a secondary metabolite and is implicated in biocontrol properties and pathogenicity exerted by other bacteria (Ryall B, *et al* 2009). The Pseudomonas fragi CS11RH1 (MTCC 8984), a psychrotolerant bacterium produces hydrogen cyanide (HCN) and the seed bacterization with the isolate significantly increases the percent germination, rate of germination, plant biomass and nutrient uptake of wheat seedlings (Selvakumar, G, *et al*, 2008). Other microbial byproducts also may contribute to pathogen suppression. Hydrogen cyanide (HCN) effectively blocks the cytochrome oxidase pathway and is highly toxic to all aerobic microorganisms at pico-molar concentrations. The production of HCN by certain fluorescent pseudomonads is believed to be involved in the suppression of root pathogens. P. *fluorescens* CHA0 produces antibiotics, siderophores and HCN, but suppression of black rot of tobacco caused by *Thielaviopsis basicola* appeared to be due primarily to HCN production (Voisard et al. 1989). While it is clear that biocontrol microbes can release many different compounds into their surrounding environment, the types and amounts produced in natural systems in the presence and absence of plant disease have not been well documented and this remains a frontier for discovery.

V. Conclusion

Introduction of PGPR into agricultural practices could minimize use of toxic chemicals noxious to the environment, thus contributing to the development of sustainable agriculture. Growers can reduced dependence on chemical inputs, so biological controls can be expected to play an important role in Integrated Weed Management (IWM) systems. Despite a model describing for a successful IPM has been developed such as Good cultural practices, including appropriate site selection, crop rotations, tillage, fertility and water management, provide the foundation for successful pest management by providing a fertile growing environment for the crop has to be considered. PGPB offer an attractive alternative that contains the possibility of developing more sustainable approaches to agriculture. Finally, it is likely to be much simpler and more efficacious to select or engineer PGPB so that they confer plants with specific desirable traits than to genetically engineer the strain to developed performance in field. Further compactible study should be study with herbicide, so that PGPR can be used as consortia formulation with pesticides.

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Acceptability Index Characterization and Process for Corn Cultivars in El Salvador, Central America

By Dora Ma. Sangerman-Jarquín , José Arístides Deleón, Rita Schwentesius De Rindermann, Agustín Navarro Bravo & Bertha Sofía Larqué Saavedra

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Abstract- The objective of this 2007 study was to characterize the process of the acceptability index of the Oro Blanco, Platino, and Protemás corn cultivars, and also to identify social, economic, agricultural, and technological variables that could explain the causes of acceptance or rejection of technology, by producers who were beneficiaries of the 2006- 2007 Program for Improvement of Basic Grain and Grass Production. This acceptability study identifies strengths and weaknesses of such technology for the stages of the transfer process. The study was conducted in 2008, in Regions I and IV of El Salvador; a survey was taken, with 133 corn producers who were beneficiaries of the 2006-2007 program for promotionof basic grain and grass production. One of the most important findings was that approximately 60% of the producers were willing to cultivate the study materials during the following agricultural cycle. These project beneficiaries were willing to sow the cultivars, called QPM, Quality Protein Maize, or in Spanish ACP for "Alta Calidad de Proteína" in 96% of areas sown with QPM, in year 2007. The Oro Blanco cv had the greatest acceptability, with an acceptability index of 82.5; Protemás scored 69.6, and Platino obtained 53.7%.

Keywords: corn, protein quality, cultivars, platino, oro blanco, and protemás.

GJSFR-D Classification : FOR Code: 079999

ACCEPTABILITYINDEXCHARACTERIZATIONANDPROCESSFORCORNCULTIVARSIN ELSALVADORCENTRALAMERICA

Strictly as per the compliance and regulations of :

Acceptability Index Characterization and Process for Corn Cultivars in El Salvador, Central America

Dora Ma. Sangerman-Jarquín [α], José Arístides Deleón[σ], Rita Schwentesius De Rindermann [ρ], Agustín Navarro Bravo [ω] & Bertha Sofía Larqué Saavedra [¥]

Abstract- The objective of this 2007 study was to characterize the process of the acceptability index of the Oro Blanco, Platino, and Protemás corn cultivars, and also to identify social, economic, agricultural, and technological variables that could explain the causes of acceptance or rejection of technology, by producers who were beneficiaries of the 2006-2007 Program for Improvement of Basic Grain and Grass Production. This acceptability study identifies strengths and weaknesses of such technology for the stages of the transfer process. The study was conducted in 2008, in Regions I and IV of El Salvador; a survey was taken, with 133 corn producers who were beneficiaries of the 2006-2007 program for promotionof basic grain and grass production. One of the most important findings was that approximately 60% of the producers were willing to cultivate the study materials during the following agricultural cycle. These project beneficiaries were willing to sow the cultivars, called QPM, Quality Protein Maize, or in Spanish ACP for "*Alta Calidad de Proteína*" in 96% of areas sown with QPM, in year 2007. The Oro Blanco cv had the greatest acceptability, with an acceptability index of 82.5; Protemás scored 69.6, and Platino obtained 53.7%.

Keywords: corn, protein quality, cultivars, platino, oro blanco, and protemás.

I. Introduction

The study was conducted by means of a survey, in 2007. Quality Protein Maize Cultivars, QPM in English or ACP in Spanish were sown in Regions I and IV of El Salvador. The study was done with the participation of the beneficiaries of the Program for Improvement of Basic Grain and Grass Production, 2006-2007, supported by Ministry of Agriculture and Livestock (MAG, *Ministerio de Agricultura y Ganadería*) of El Salvador, through National Center for Agricultural and Forest Technology (CENTA, *Centro Nacional de Tecnología Agropecuaria y Forestal*).

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II. Materials and Methods

a) Study area

The areas selected were in the western and eastern regions of El Salvador, identified as Regions I and IV, because they have the greatest amount of malnutrition problems. Region I includes the departments of Santa Ana, Sonsonate, and Ahuachapán, where 62803 ha are cultivated, on 26% of national soil, where an average yield of 2140 kg $ha^{-1}$was reached (MAG-DGEA, 2007). It is important to mention that for the calculations regarding the hybrid corn Oro Blanco, the municipalities of La Nueva Concepción and La Palma from the department of Chalatenango were included, and that, although they politically and administratively correspond to Region II, within the institutional structure of CENTA they are considered Region I (Figure 1).

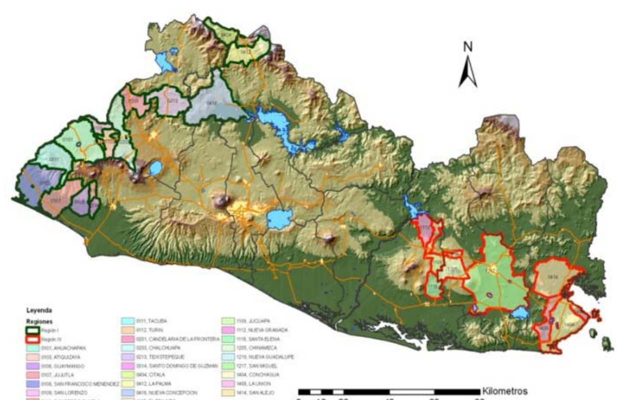

Figure 1 : Location of beneficiaries per municipality in the 2006-2007 Program for the Promotion of Basic Grain and Grass Production.

Region IV includes the departments of La Unión, San Miguel, Morazán, and Usulután, where 85 837 ha of corn are cultivated (MAG-DGEA, 2007), on 35.6% of the national cultivation surface area. In that region, 33.2% of national grain production is harvested and an average yield of 2010 kg ha-1 is obtained. The total number of producers that sowed QPM corn for the first time in 2007, with one or more of the following cultivars: Platino (281), Oro Blanco (60) and Protemás (200), was 541 growers (Figure 1).

b) Sample

From a total of 541 beneficiaries that in 2007 had contact with the technology in one of the 15 extension agencies located in the western and eastern regions, 133 (almost 25%), were selected at random, from which 36 producers sowed Oro Blanco, 73 Platino, and 25 Protemás, respectively. The seeds that they used were supplied by the "2006-2007 Program for the Promotion of Basic Grain and Grass Production," sponsored by CENTA-MAG.

c) Data evaluated

This work was performed in the field, beginning with information gathering, through a survey with a target population in the study area, for which a survey team was hired, with their respective supervisors, in both regions.

The next step was the data verification phase, a second visit or a "revisit" to a producer, conducted by field supervisors at random.

d) Available information

- MAG-CENTA Program records regarding seed allotment to the producers that received the corn cultivars evaluated in the study area.
- Information gathered from "Record of Materials and Hybrid Quality Protein Maize," modified for local conditions in the study area.
- Database from the 2007 Population and Housing Census taken in El Salvador: a tool for census exploitation and online interactive maps.
- PASOLAC (PASOLAC, IICA) The Acceptability Index (AI) Methodology used to estimate the cultivation acceptability index, modified for local conditions in this study.

e) Characteristics of the cultivars evaluated in the study

- Oro Blanco. A white grain hybrid quality protein maize(HI= 92% (CENTA-MAG, 2008)), with a potential yield of 7143 kg ha-1 and an average yield of 4870 kg ha-1. It has good size and ear structure, with excellent coverage; a crystalline grain texture, and is tolerant to weevil damage and relatively tolerant to erratic precipitation and conditions.
- Platino. A white grain hybrid quality protein maize (HI= 90%). Has a potential yield of 6494 kg ha-1 and average yield of 4 545 kg ha-1. It has good size and ear structure, and excellent coverage; a crystalline grain texture, and is tolerant to weevil damage and relatively tolerant to erratic precipitation and conditions.
- Protemás. A corn variety, a free-pollination cultivar of white semi crystalline grain, a quality protein maize (HI= 90%); potential yield of 5844 kg ha-1 and average yield of 3701 kg ha-1. Good size and ear structure and excellent coverage. Good root system that provides strong support.

f) Acceptability Index (AI)

The acceptability index is a simple tool designed for monitoring technology transfer activities, developed by the PASOLAC Project in 1999.

The Acceptability Index is part of a group of socioeconomic tools that are used in the introductory and participatory processes of diffusion of agricultural technologies, and in the monitoring of these technologies. This process begins with technology validation, then a transfer period, and finally allows researchers to determine whether or not the study technology provides the specific production, consumption, and commercialization conditions that will satisfy the needs of the producers that use them.

This acceptability study was conducted in order to identify strengths and to adjust the weaknesses of a technology that is in the transfer process stage. It was expected with this first important QPM technology transfer effort run by the government, that producers should have the opportunity to implement a recently understood practice and that an initial idea of acceptance or rejection might be gained, which is the objective of this tool.

This study evaluated the extent to which QPM corn, specifically the Platino, Oro Blanco, and Protemás cultivars, were accepted by the beneficiaries of CENTA's program, so that their decision to accept or to reject technology might be based on results obtained in a previous crop with these materials. The AI of a variety is mathematically calculated using base years for calculation and comparison, and percentages of total producers and areas sown with QPM corn, as shown in the following general formula:

g) General acceptability index formula

$$\text{AI (Acceptability Index)} = \frac{(\text{\% of producers applying the technology}) \times (\text{\% of area involved})}{100}$$

h) Adapted formula for calculation of the acceptability index

This study used an adapted formula that we will call the acceptability index, adapted from PASOLAC 1999.This formula was used to compare data regarding producers that used QPM technology in 2007, with producers that expressed their desire to apply the technology in 2008, if they were given the seed or if it were available in the market.

$$\text{Acceptability Index} = \frac{\left[\left[\frac{\text{QPMProducers 2008}}{\text{QPMProducers 2007}}\right] \times 100\right] \times \left[\left[\frac{\text{QPMArea 2008}}{\text{QPMArea 2007}}\right] \times 100\right]}{100}$$

- QPM Prod. 08= number of producers sampled that would apply QPM technology in 2008 if there were seed available on the market.
- QPM Prod. 07= number of producers that applied the technology in 2007.
- QPM Area 08= area where the technology would be applied as per the producer's free will, if there were seed in the market in 2008.
- QPM Area 07= total area sown with QPM corn in 2007.

III. Results

a) Re-structuring of corn production, 1996-2008

From 1996 to 2008, the government of El Salvador made important efforts to restructure national corn production. One of these efforts was the promotion of the use of hybrid and improved cultivars, in which success has been achieved of up to 77% as regards the adoption of these materials by producers (MAG-DGEA, 2007) at the national level.

The practice has increased cultivation yields in the last decade, from an average of 2169 kg ha^{-1} in 1996, to 3078 kg ha-1in 2006 (MAG-DGEA, 2007).

The following figure shows surface area, production, and yield for the 1996-2007 period, and uses the year 2000 as a baseline, as 100%, for the calculation of the indices (MAG-DGEA, 2007) (Figure 2).

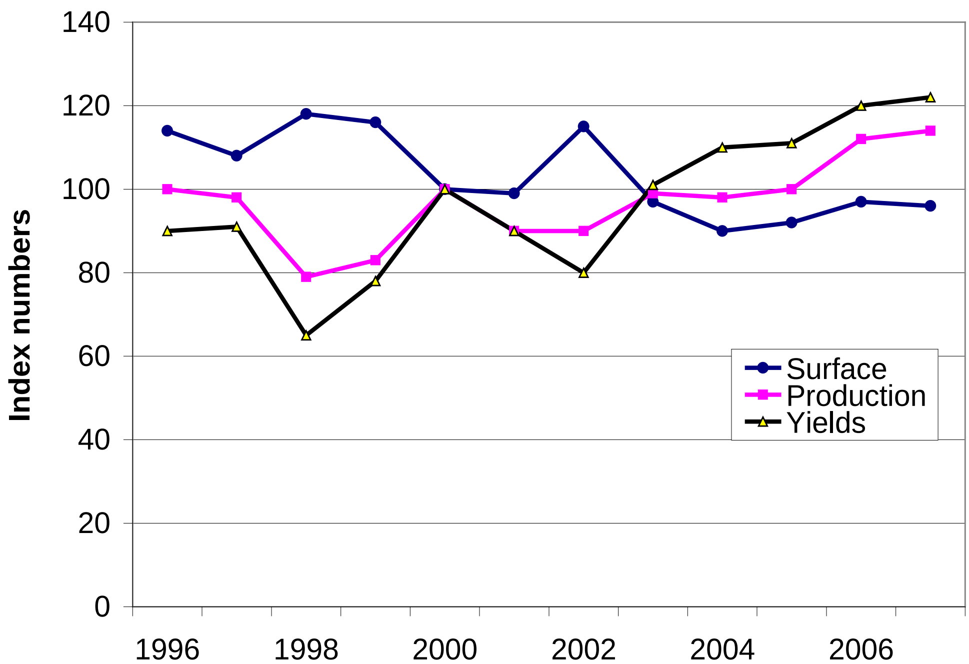

Figure 2 : Surface, production, and yield indices in corn cultivation 1996-2007, in El Salvador, C.A. (year 2000= 100).

Surface areas used for corn cultivation decreased by 18.2%, which reduced the production of approximately 4,000 producers per year. However, in spite of this decrease in area, there was an increase in production in same period, by 41.9% kg ha^{-1}, which represented an increase in national production by 16% of total produced volume. Thus, between 2006 and 2007, CENTA's technology transfer process gained new ground with respect to the solution, through the implementation of the "2006-2007 Program for the Promotion of Basic Grain and Grass Production" (CENTA-PAO, 2006-2007).

Production of these three corn cultivars requires more arable land per ingested calorie, and production per hectare of legumes is usually less than that of cereals (CIMMYT- PURDUE, 1977): challenges in the process of diffusion of the technology. In this context, 336163 Mz [234911 ha] of corn are cultivated in the country on average; with contribution of the seeds distributed by the project, an added cultivation of 40488Mz [28 293 ha] has been achieved, 12% of the cultivated area at a national level (CENTA, 2008).

b) Nutritional Characterization of Evaluated Cultivars

For some time, national and international institutions have agreed that the child population of El Salvador has some type of malnutrition, reaching levels up to 57% in rural areas (CENTA-MAG, 2007). The diet consumed by most of the population of El Salvador consists mainly of corn and beans.

These diets currently consumed are not efficient in providing high quality proteins.

Studies have shown that the nutritional value of one's diet improves when it is supplemented with lysine and tryptophan, which are found in the QPM corns Oro Blanco, Platino, and Protemás (CENTA AGRO INNOVACIÓN 2007). These non-transgenic varieties are considered Quality Protein Maize by the International Maize and Wheat Improvement Center (CIMMYT, *Centro Internacional de Mejoramiento de Maíz y Trigo*). This type of corn represents a significant improvement in nutritional level for human and animal consumption over common corn and hybrid materials, which have been used in El Salvador for the past ten years.

The social groups that are able to benefit from implementation of QPM corn cultivation are: (1) the poor rural class which consumes most of the production; (2) the urban poor class; (3) the producer class that produces grain and food for livestock; (4) the commercial grain producers; and (5) the mainstream consumer group.

c) Calculation of 2008acceptability index for QPM material

The original concept of the acceptability index for monitoring the early diffusion of agricultural technologies was established some years ago by Hildebrand and Poey, in 1999. They reported that a technology can have success in acceptance when the percentage of growers that accept it is at least 50%, and at the same time, the numerical index value should be at least 25 units.

Acceptability Index calculated based on2008 survey data, as shown in Table 1.

Table 1 : Acceptability Index of QPM material in Regions I and IV in El Salvador, Central America.

Geographic Area	Variety	No. QPM Prod. 07	No. QPM Prod. 08	(%) Prod. 08/07	QPM Area 07	QPM Area 08	(%) Area 08/07	AI 2008
National	QPM	133	80	60.15	75	71	94.67	56.94
National	Oro Blanco	36	24	66.67	21	26	123.81	82.54
National	Protemás	24	13	54.17	7	9	128.57	69.64
National	Platino	73	49	67.12	45	36	80.00	53.70
Region I	QPM	75	46	61.33	47	44	93.62	57.42
Region I	Oro Blanco	20	9	45.00	13	17	130.77	58.85
Region I	Protemás	0	0	0.00	0	0	0.00	0.00
Region I	Platino	55	37	67.27	32	27	84.38	56.76
Region IV	QPM	58	37	63.79	28	27	96.43	61.51
Region IV	Oro Blanco	16	12	75.00	8	10	125.00	93.75
Region IV	Protemás	24	13	54.17	7	9	128.57	69.64
Region IV	Platino	18	12	66.67	13	9	69.23	46.15

Source: own field work.

Table 1 shows that 60.1% of the surveyed producers, beneficiaries of the project for allotment of QPM corn seed in 2007(80 of a total 133), were willing to cultivate 94.6% of their surface area (71 out of 75 ha), and that they would be willing to sow during the next agricultural cycle.

It is observed, according to the results of the 2008 acceptability index regarding the producers benefitting from the 2007 allotment of QPM corn seed, that of the study material, the hybrid corn Oro Blanco was the most highly-rated cultivar, with a general acceptability index in both regions, of 82.5; in second place, Protemás obtained AI= 69.6 and Platino, in third place, scored AI= 53.7. Oro Blanco is an exceptional case, 82.5%; 23% of the total producers were willing to sow an extra area of the total surfaces during the study; that is to say that the index of acceptability of the technology, subject to available seed in the market, exceeded the areas that will be dedicated thereto in the next agricultural cycle, for the areas in which the survey was taken.

Similarly, with Protemás; 67.1%, 28.5% of the producers benefitting from the 2007 allotment of QPM corn seed were willing to sow an area that was greater than 100% of the area sown.

With respect to the acceptance level of the study material from a geographical point of view, at the regional level, it was found that the producers' willingness with regard to new technology in Region I was AI= 57.4, while in Region IV it was AI= 61.5, although with the data gathered, it was not possible to determine the cause of difference in the index between both regions. When comparing the acceptability indices between evaluated materials and their geographical location, it can be observed that Oro Blanco in Region I has a much lower acceptability (AI= 58.8) than in Region IV (AI= 93.7); Platino had an opposite behavior, being more accepted in Region I (AI= 56.7) than in Region IV (AI= 46.1). Protemás was not cultivated in Region I, while it had an AI= 69.6 in Region IV. This shows that distribution of QPM material can be adapted based on acceptability index, to the geographical environment.

d) Nutritional Quality of QPM Material

The nutritional quality of QPM corn, measured based on protein percentages and tryptophan contents, was determined in a laboratory in the study conducted by (Déras, 2008) (CENTA-MAG, 2007). The findings of this investigation were consistent with the results obtained in similar studies, carried out at the University of Purdue, where it was also established by laboratory analysis that QPM corns contain at least twice the amount of the essential amino acid tryptophan and it was also determined that they have a quality index greater than 0.80 (CENTA-MAG, 2007).

Table 2 shows that, of the cultivars studied, QPM corns have a quality index higher than or similar to 0.90, which puts them far above some traditional hybrids used by corn producers, such as H-59 with a value in the table of 0.40.

Table 2 : Analysis of grain and seed quality of QPM hybrids and common hybrid corn.

Hybrids	Nitrogen	Protein	Triptophan	Quality Index
H-59 (grain)	1.64	10.23	0.04	0.40
Oro Blanco (grain)	1.72	10.78	0.103	0.96
Oro Blanco (seed)	1.82	11.38	0.104	0.91
Platino (grain)	1.53	9.50	0.092	0.96
Platino (seed)	2.01	12.54	0.113	0.90

Source: own field work.

Another consistent conclusion was drawn from preliminary study results on consumption of corn carried out in the country, with children under two years of age, in the El Havillal neighborhood, in the municipality of Conchagua, La Unión, El Salvador. The study concluded that consumption of the QPM material was correlated with a better probability of weight increase than with consumption of traditional hybrid corn (CENTA-MAG, 2007). This confirms that when including QPM corns in some type of human or animal diet, the proteins that previously were only obtained by a good combination of cereals and legumes or animal proteins are provided to the consumer (CIMMYT PURDUE, 1977).

e) Current use of corn areas

In the last decade, national corn cultivation policy has changed in response to global commercial policies of regional and international integration. Producers have developed a capacity for response that has allowed them to constantly innovate technologies used for production, with government support guiding the use of improved and hybrid corns.

According to survey results, those corn producers in El Salvador are classified as small farmers, based on the surface area used for cultivation, since 40% of cultivation areas sown in the study area were smaller than one hectare. 48% was cultivated in parcels of up to 2.4 hectares and the remaining 12% in areas of between 2.3 and 5 hectares of cultivation. With respect to the owners of land in general used for corn cultivation, according to survey, the use of their land has increasingly involved own lands and higher-quality land; the smallest production was done on leased lands and lands of lesser quality. Thus, 65% of the total area sown with corn (187 ha), in the conduct of the study; was done on own properties, while 29% (84 ha) was cultivated on leased lands, and the remaining lands were borrowed lands or involved another similar type of use.

In general, the use of economic resources (surface area, especially) is perceived to be prioritized for corn cultivation, with the purpose of increasing productivity. To the extent that this new way of production is developed, producers will increase the corn quantities they market for consumption as shown in Table 3.

Table 3 : Yields between QPM and hybrid corns.

Comparison of yields of QPM cultivars, and of other hybrids					95% confidence interval for the difference	
	t	Degrees of freedom	SIG (two-tailed)	Difference of means kg ha^{-1}	Lowest kg ha^{-1}	Highest kg ha^{-1}
Yields of QPM cultivars 2007	26.0	131	0.00	2375	2195	2555
Yields of other hybrids	18.1	132	0.00	2939	2620	3259

Test value= 0. Source: own field work.

When stratifying producers, based on production sensitivity analysis, 2 types were identified: commercial producers, because all their production is for sale, and subsistence producers, who produce for self-consumption and a small portion for sale. A significant difference was found between yields of hybrid and QPM corn, of 564 kg ha^{-1} on average, 425 kg ha-1 in the lower limit and 704 kg ha^{-1}at the higher limit, for both subsistence and commercial producers. Translated into revenues, this equals U.S. $149 per hectare, which reflects a reduced cultivation profitability on average; the lower limit was U.S. $112 and the higher limit was U.S.

$185. For this reason, producers perceive that hybrid cultivars are more profitable and more competitive.

With regard to net profit when comparing QPM corn with traditional hybrid corn, the growing of corn at the national level produces an average income of U.S. $700 per ha with an investment cost of U.S. $516 ha, which results in a net profit of U.S. $184 ha^{-1} (Table 4).

Table 4 : Comparison of profitability between hybrid and ACP corns, 2007.

Economic situation of the producers		Average income \$ ha^{-1} of corn	Average costs \$ ha^{-1} of corn	Average profit \$ ha^{-1} of corn	Net average profit \$ ha^{-1} of QPM cultivars	Net average profit \$ ha^{-1} of other hybrids
N	Overall	132	133	132	132	133
Average		700.6	516	184.0	-69.9	80.9
Percentiles	25	421.6	403.6	-40.9	-301.1	-166.0
	50	724.4	603.3	196.5	-108.2	168.2
	75	946.2	641.2	411.3	168.8	442.3

Source: own field work.

When comparing average net profits from hybrid corns against QPM material, using 2007 data, it can be seen that the hybrids obtained US$80 ha^{-1} while QPM corn showeda deficit of approximately U.S. $69 ha.

As for the statistical distribution of data, the 25thpercentile, as well as the hybrid cultivars (U.S. $-166 ha^{-1}) and QPM (U.S. $-310 ha^{-1}) show a negative result, although the economic loss for the traditional hybrid is smaller. The situation with the 50th percentile is similar for both that obtain a positive result, but always in favor of hybrid corn (U.S. $168 ha^{-1}). Finally, at the 75th percentile the profitability of both is positive, but the hybrid corn is always much higher (U.S. $442.3 ha^{-1}). Thus, the difference in income per sale of hybrid materials for an average family is increased to 3,356 kg compared with the 1295 kg produced with QPM corns.

IV. Discussion

a) New acceptability index paradigm

The paradigm changes in current corn production in El Salvador are closely related to the transformation of subsistence production into business agriculture, to market, as well as the introduction of new technology and cultivars. The producer acquires economic motivation by incorporating new technologies to its cultivation system, with a prospect of good yields, grain quality, and greater production profitability. Institutions have promoted a new system for producer decision-making with regard to innovations in their production systems. This system should be based on the social environment of the producer, where food security for his family, the desire for economic improvement, and the technological factor, are key factors at this time in the decision to adopt new cultivars.

b) Family size

With relationship to this variable, a tendency to consolidate in small groups has been observed in recent decades with regard to the sizes of families in the rural areas of El Salvador. According to survey results, in the eastern and western regions of the country, the average size of a family unit is five members. However, women of childbearing age (between 15 and 49 years of age) and children younger than 3 years of age constitute approximately 40% of the family unit and of the rural population in general. An average rural family in El Salvador consumes in tortillas and other daily uses of corn a total of 2.5 kg at an average price of U.S. $0.22 (2008), with a daily investment of US$0.54, and a total of 958.2 kg annually with a value of U.S. $210.

The importance of corn consumption in the Salvadoran population's basic diet is obvious, whether as tortillas or some other derivative of the grain. Thus, if families have low income and a diet almost exclusively based on beans and corn with low nutritional content, this population becomes a vulnerable population as regard sits physical and social development. It can be inferred, then, that it would be advantageous for farmers to replace the hybrid cultivars that they currently use with QPM corn. Based on the size of the family unit, this is statistically acceptable since if the family is large and has the alternative of offering a high quality corn, it is logical to bet on this alternative, to offer an higher level of food security.

c) Interaction of the model in the acceptability index

The acceptability index is presented in the study, as part of systemic model in which exogenous and endogenous structures interact and determine the interdependence of subsystems; they explain the acceptance or rejection of the technology. It is formed from a real concept of producers and explains the behavior of acceptability index levels in El Salvador. Exogenous factors, products of the transformation of the current global economic situation, demand the integration and re-adaptation of the national agricultural economy. Profound technological changes linked to historical factors are necessary in order to maintain the competitiveness of the family corn production units in El Salvador.

The generation of technologies, technical support, and policies that promote productivity heretofore proposed constitute the way in which producers can learn about the benefits of new QPM material and become willing to replace traditional technologies with new ones. In the agricultural subsystem, in spite of the importance of QPM material due toits nutritional quality and its suitability for domestic consumption, among producers there is the perception that the hybrid corns they already use are preferable because they generate greater income per sale. This study concludes that in El Salvador, nearly 77% of national producers use certified seed, and 60% of this group is interested in cultivating QPM corn.

In synthesis, the new paradigm has led to a change in the profile of a farmer, in which currently they are characterized as land owners with greater experience in cultivation. The culture of hybrid materials has been established, using greater areas and better quality soils, as well as acultivation centered around commercial sales. To evaluate the acceptability index of new seed technologies that are introduced in the Salvadorian agriculture such as QPM corn, it is necessary to adopt a transitional approach with regard to the current processes implemented by the Salvadorian producers.

V. Conclusions

The acceptability index of QPM material in Region I and IV of El Salvador reflects that these materials are accepted by approximately 60% of the corn producer population, which is willing to sow in future cycles nearly 33% of the total areas cultivated in 2007, the year in which the study was conducted. The reason why only 60% of producers accepted this technology is due to the fact that QPM corn obtained a yield that was 564 kg ha^{-1}lower than that of the hybrid corn, the average yield for which was 2939 kg ha^{-1}, equivalent to U.S. $149 per hectare, affecting cultivation profitability. However, among the producers that accept QPM, 43.5% consider that they are affected by yields, and 45.4% perceive that the protein quality is superior, both for human and animal consumption.

Of the QPM cultivars included in the study, the hybrid Oro Blanco is the most-favored with a general acceptability index of 82.54; Protemás, in second place, obtained an index of 69.64, while the acceptability index of the hybrid corn Platino was 53.70. In Region IV Oro Blanco was the most accepted hybrid, while in Region I the most accepted hybrid was Platino.

When establishing social, economic, agricultural, and technological factors as causes influencing the determination of the acceptability index, each level plays its specific role. Some factors such as the economic factor strongly determine decision-making by producers, with regard to the use of these materials, in future agricultural cycles.

The technology supported by MAG-CENTA, in technology generation and transfer, is showing a good level of acceptance by producers, in spite of current limitations, such as these QPM materials' need for greater promotion and field testing by means of demonstration parcels, which aim to verify through field work the advantages of QPM corn over hybrid material.

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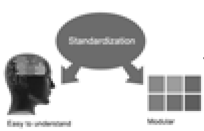

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The IFOARS institution is entitled to form a Board comprised of one Chairperson and three to five board members preferably from different streams. The Board will be recognized as "Institutional Board of Open Association of Research Society"-(IBOARS).

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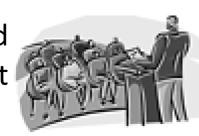
The author fees of such paper may be waived off up to 40%.



The Global Journals Incorporation (USA) at its discretion can also refer double blind peer reviewed paper at their end to the board for the verification and to get recommendation for final stage of acceptance of publication.

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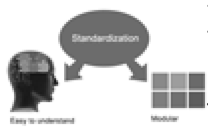

After nomination of your institution as "Institutional Fellow" and constantly functioning successfully for one year, we can consider giving recognition to your institute to function as Regional/Zonal office on our behalf.

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The following entitlements are applicable to individual Fellows:

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Note :

"

- In future, if the board feels the necessity to change any board member, the same can be done with the consent of the chairperson along with anyone board member without our approval.
- In case, the chairperson needs to be replaced then consent of 2/3rd board members are required and they are also required to jointly pass the resolution copy of which should be sent to us. In such case, it will be compulsory to obtain our approval before replacement.
- In case of "Difference of Opinion [if any]" among the Board members, our decision will be final and binding to everyone.

"

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1. General,

2. Ethical Guidelines,

3. Submission of Manuscripts,

4. Manuscript's Category,

5. Structure and Format of Manuscript,

6. After Acceptance.

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The recommended size of original research paper is less than seven thousand words, review papers fewer than seven thousands words also.Preparation of research paper or how to write research paper, are major hurdle, while writing manuscript. The research articles and research letters should be fewer than three thousand words, the structure original research paper; sometime review paper should be as follows:

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(g) Discussion should cover the implications and consequences, not just recapitulating the results; conclusions should be summarizing.

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28. Make colleagues: Always try to make colleagues. No matter how sharper or intelligent you are, if you make colleagues you can have several ideas, which will be helpful for your research.

29. Think technically: Always think technically. If anything happens, then search its reasons, its benefits, and demerits.

30. Think and then print: When you will go to print your paper, notice that tables are not be split, headings are not detached from their descriptions, and page sequence is maintained.

31. Adding unnecessary information: Do not add unnecessary information, like, I have used MS Excel to draw graph. Do not add irrelevant and inappropriate material. These all will create superfluous. Foreign terminology and phrases are not apropos. One should NEVER take a broad view. Analogy in script is like feathers on a snake. Not at all use a large word when a very small one would be sufficient. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Amplification is a billion times of inferior quality than sarcasm.

32. Never oversimplify everything: To add material in your research paper, never go for oversimplification. This will definitely irritate the evaluator. Be more or less specific. Also too, by no means, ever use rhythmic redundancies. Contractions aren't essential and shouldn't be there used. Comparisons are as terrible as clichés. Give up ampersands and abbreviations, and so on. Remove commas, that are, not necessary. Parenthetical words however should be together with this in commas. Understatement is all the time the complete best way to put onward earth-shaking thoughts. Give a detailed literary review.

33. Report concluded results: Use concluded results. From raw data, filter the results and then conclude your studies based on measurements and observations taken. Significant figures and appropriate number of decimal places should be used. Parenthetical remarks are prohibitive. Proofread carefully at final stage. In the end give outline to your arguments. Spot out perspectives of further study of this subject. Justify your conclusion by at the bottom of them with sufficient justifications and examples.

34. After conclusion: Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium though which your research is going to be in print to the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects in your research.

Informal Guidelines of Research Paper Writing

Key points to remember:

- Submit all work in its final form.
- Write your paper in the form, which is presented in the guidelines using the template.
- Please note the criterion for grading the final paper by peer-reviewers.

Final Points:

A purpose of organizing a research paper is to let people to interpret your effort selectively. The journal requires the following sections, submitted in the order listed, each section to start on a new page.

The introduction will be compiled from reference matter and will reflect the design processes or outline of basis that direct you to make study. As you will carry out the process of study, the method and process section will be constructed as like that. The result segment will show related statistics in nearly sequential order and will direct the reviewers next to the similar intellectual paths throughout the data that you took to carry out your study. The discussion section will provide understanding of the data and projections as to the implication of the results. The use of good quality references all through the paper will give the effort trustworthiness by representing an alertness of prior workings.

Writing a research paper is not an easy job no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record keeping are the only means to make straightforward the progression.

General style:

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

To make a paper clear

· Adhere to recommended page limits

Mistakes to evade

- Insertion a title at the foot of a page with the subsequent text on the next page
- Separating a table/chart or figure - impound each figure/table to a single page
- Submitting a manuscript with pages out of sequence

In every sections of your document

· Use standard writing style including articles ("a", "the," etc.)

· Keep on paying attention on the research topic of the paper

· Use paragraphs to split each significant point (excluding for the abstract)

· Align the primary line of each section

· Present your points in sound order

· Use present tense to report well accepted

· Use past tense to describe specific results

· Shun familiar wording, don't address the reviewer directly, and don't use slang, slang language, or superlatives

· Shun use of extra pictures - include only those figures essential to presenting results

Title Page:

Choose a revealing title. It should be short. It should not have non-standard acronyms or abbreviations. It should not exceed two printed lines. It should include the name(s) and address (es) of all authors.

Abstract:

The summary should be two hundred words or less. It should briefly and clearly explain the key findings reported in the manuscript--must have precise statistics. It should not have abnormal acronyms or abbreviations. It should be logical in itself. Shun citing references at this point.

An abstract is a brief distinct paragraph summary of finished work or work in development. In a minute or less a reviewer can be taught the foundation behind the study, common approach to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Yet, use comprehensive sentences and do not let go readability for briefness. You can maintain it succinct by phrasing sentences so that they provide more than lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study, with the subsequent elements in any summary. Try to maintain the initial two items to no more than one ruling each.

- Reason of the study - theory, overall issue, purpose
- Fundamental goal
- To the point depiction of the research
- Consequences, including definite statistics - if the consequences are quantitative in nature, account quantitative data; results of any numerical analysis should be reported
- Significant conclusions or questions that track from the research(es)

Approach:

- Single section, and succinct
- As a outline of job done, it is always written in past tense
- A conceptual should situate on its own, and not submit to any other part of the paper such as a form or table
- Center on shortening results - bound background information to a verdict or two, if completely necessary
- What you account in an conceptual must be regular with what you reported in the manuscript
- Exact spelling, clearness of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else

Introduction:

The **Introduction** should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable to comprehend and calculate the purpose of your study without having to submit to other works. The basis for the study should be offered. Give most important references but shun difficult to make a comprehensive appraisal of the topic. In the introduction, describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will have no attention in your result. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here. Following approach can create a valuable beginning:

- Explain the value (significance) of the study
- Shield the model - why did you employ this particular system or method? What is its compensation? You strength remark on its appropriateness from a abstract point of vision as well as point out sensible reasons for using it.
- Present a justification. Status your particular theory (es) or aim(s), and describe the logic that led you to choose them.
- Very for a short time explain the tentative propose and how it skilled the declared objectives.

Approach:

- Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done.
- Sort out your thoughts; manufacture one key point with every section. If you make the four points listed above, you will need a least of four paragraphs.

- Present surroundings information only as desirable in order hold up a situation. The reviewer does not desire to read the whole thing you know about a topic.
- Shape the theory/purpose specifically - do not take a broad view.
- As always, give awareness to spelling, simplicity and correctness of sentences and phrases.

Procedures (Methods and Materials):

This part is supposed to be the easiest to carve if you have good skills. A sound written Procedures segment allows a capable scientist to replacement your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt for the least amount of information that would permit another capable scientist to spare your outcome but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section. When a technique is used that has been well described in another object, mention the specific item describing a way but draw the basic principle while stating the situation. The purpose is to text all particular resources and broad procedures, so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step by step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

- Explain materials individually only if the study is so complex that it saves liberty this way.
- Embrace particular materials, and any tools or provisions that are not frequently found in laboratories.
- Do not take in frequently found.
- If use of a definite type of tools.
- Materials may be reported in a part section or else they may be recognized along with your measures.

Methods:

- Report the method (not particulars of each process that engaged the same methodology)
- Describe the method entirely
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures
- Simplify - details how procedures were completed not how they were exclusively performed on a particular day.
- If well known procedures were used, account the procedure by name, possibly with reference, and that's all.

Approach:

- It is embarrassed or not possible to use vigorous voice when documenting methods with no using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result when script up the methods most authors use third person passive voice.
- Use standard style in this and in every other part of the paper - avoid familiar lists, and use full sentences.

What to keep away from

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings - save it for the argument.
- Leave out information that is immaterial to a third party.

Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part a entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Carry on to be to the point, by means of statistics and tables, if suitable, to present consequences most efficiently.You must obviously differentiate material that would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matter should not be submitted at all except requested by the instructor.

Content

- Sum up your conclusion in text and demonstrate them, if suitable, with figures and tables.
- In manuscript, explain each of your consequences, point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation an exacting study.
- Explain results of control experiments and comprise remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or in manuscript form.

What to stay away from

- Do not discuss or infer your outcome, report surroundings information, or try to explain anything.
- Not at all, take in raw data or intermediate calculations in a research manuscript.
- Do not present the similar data more than once.
- Manuscript should complement any figures or tables, not duplicate the identical information.
- Never confuse figures with tables - there is a difference.

Approach

- As forever, use past tense when you submit to your results, and put the whole thing in a reasonable order.
- Put figures and tables, appropriately numbered, in order at the end of the report
- If you desire, you may place your figures and tables properly within the text of your results part.

Figures and tables

- If you put figures and tables at the end of the details, make certain that they are visibly distinguished from any attach appendix materials, such as raw facts
- Despite of position, each figure must be numbered one after the other and complete with subtitle
- In spite of position, each table must be titled, numbered one after the other and complete with heading
- All figure and table must be adequately complete that it could situate on its own, divide from text

Discussion:

The Discussion is expected the trickiest segment to write and describe. A lot of papers submitted for journal are discarded based on problems with the Discussion. There is no head of state for how long a argument should be. Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implication of the study. The purpose here is to offer an understanding of your results and hold up for all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of result should be visibly described. Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved with prospect, and let it drop at that.

- Make a decision if each premise is supported, discarded, or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."
- Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work
- You may propose future guidelines, such as how the experiment might be personalized to accomplish a new idea.
- Give details all of your remarks as much as possible, focus on mechanisms.
- Make a decision if the tentative design sufficiently addressed the theory, and whether or not it was correctly restricted.
- Try to present substitute explanations if sensible alternatives be present.
- One research will not counter an overall question, so maintain the large picture in mind, where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

- When you refer to information, differentiate data generated by your own studies from available information
- Submit to work done by specific persons (including you) in past tense.
- Submit to generally acknowledged facts and main beliefs in present tense.

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- Do not give permission to anyone else to "PROOFREAD" your manuscript.
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- To guard yourself and others from possible illegal use please do not permit anyone right to use to your paper and files.

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	A-B	**C-D**	**E-F**
Abstract	Clear and concise with appropriate content, Correct format. 200 words or below	Unclear summary and no specific data, Incorrect form Above 200 words	No specific data with ambiguous information Above 250 words
Introduction	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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