THE CULTIVATION AND PHENOLOGICAL GROWTH STAGES OF YACON [SMALLANTHUS SONCHIFOLIUS (POEPP. ET ENDL.) H. ROBINSON

FERNÁNDEZ C.E., VIEHMANNOVÁ I., BECHYNĚ M., LACHMAN J., MILELLA L., MARTELLI G.

Abstract
Yacon (Smallanthus sonchifolius), a native plant of the Andes, belongs to the family Asteraceae. Four genotypes of yacon obtained from Germany, New Zealand, Ecuador and Bolivia were cultivating on the trial fields of The Institute of Tropics and Subtropics of CUA during 2001–2004. During this period the growth and development of plants were studied. On the basis of knowledge of morphology and the dynamics of plant development a macrophenological scale (according to BBCH scale) was elaborated, which collects ten principal growth stages: 0 Sprouting, 1 Leaf development, 2 Ramification, 3 Crop cover, 4 Formation of tuberous roots, 5 Bud formation, 6 Flowering, 7 Formation of achenes, 8 Maturity of achenes, 9 Senescence. Prior to reaching full maturity of tuberous roots the vegetation is finished as a result of the coming of early autumn frosts. The elaboration of a phenological scale could help to contribute to the optimal cultivation method and the dates of agrotechnical interventions in field conditions during the vegetation period. Cultivation of yacon in Czech Republic showed that this crop could be successfully cultivated in the conditions of Central Europe. The length of the vegetation period is the only limiting factor, because it is restricted by spring and autumn frosts.

Key words: yacon, *Smallanthus sonchifolius*, BBCH scale, phenology, vegetation period

INTRODUCTION

Yacon [Smallanthus sonchifolius (Poepp. et Endl.) H. Robinson, Asteraceae] is a tuberous plant native to the Andes. It is a perennial plant, but regarding the system of its cultivation is an annual plant. Yacon, as opposed to most tuberous and root crops, which deposit saccharides in the form of starch, cumulates saccharides in the form of fructooligosaccharides (FOS) of inulin type. These FOS are not metabolized in the human digestive tract and hence their consumption does not enhance the level of glucose in the blood. This is the reason why yacon is considered to be a food with a high potential for diabetics. Tuberous roots, which possess a low energy value, are also an ideal foodstuff for people suffering from obesity. They are also rich source of antioxidants of a phenolic character contained above all in the leaves (Lachman et al., 2003). Tuberous roots could be also used as a feedstuff for cattle, sheep and other domestic animals. Above ground green matter with the content 12.8–25.5% of proteins in dry matter is useful as fodder.
Yacon radical system is densely ramified. It constitutes a vast system of cylindrical roots (non storage roots) and tuberous roots (storage roots) of an adventitious nature. The latter are pretty irregular in shape, between spindle-shaped and round-shaped (a little similar to those of the common dahlia), and can vary considerably with respect to shape, size, and sweetness. Around the base of the stem up to 20 tuberous roots could be arranged. Externally, the tuberous roots could be brown, pink, purple, cream, or ivory, with a skin between 1 mm and 2 mm thick. Internally, they are white-, cream-, yellow-, purple-, or pink-colored, sometimes white with purple striae. The pulp is fleshy, crunchy and sweet. Generally, in the Andes each tuberous root weights between 200 g and 500 g, although they can reach up to 2000 g. The yacon rises up to 1.5 m to 3 m in height in the Andean climatic conditions. Two kinds of stems are present in this plant species: aboveground and underground. The above-ground stems are thick, cylindrical or a little angular, striated, densely pilous – especially on the upper part – and with purple lines. These stems tend to radially incline from the center to the outside, at a distance equivalent to their height. Although succulent when young, they tend to harden (lignify) and form a hole through their central axis as they get older. When dry, they commonly acquire a yellowish-orange colour. The underground stems form a system of short, thick, and sympodial rhizomes, which are used in order to vegetatively propagate this plant species. Although they are not usually eaten, these rhizomes are edible (León, 1964).
The leaves are the opposite, dark-green, large, and variable in shape. The lower leaves are widely ovate and hastate or sub-hastate. Their margin is dentate, and the teeth have calli at their tips. The base of the expanded portion of the leaf blade is triangular or abruptly cuneate. The petiole possesses wings up to 40 mm wide and 140 mm long. At the base, the lower leaves are auriculate and connate. The upper leaves are ovate-lanceolate, with no lobes or hastate bases, and with densely glandulous-pilose petioles. Both, the adaxial and abaxial leaf faces of all the leaves, present trichomes (0.8 mm to 1.5 mm long, and 0.05 mm in diameter) and glands containing terpenoid compounds (León, 1964).
The flowers are somewhat scarce, which is a common feature among clonally propagated tuberous crops. They are arranged in capitula (heads) that are born on 1 to

5 axes, each one with 3 capitula. These inflorescences are terminal. The delicate flower heads are small, approximately 250 mm in diameter and yellow or light orange. The central flowers (disc flowers) are staminate, tubular, and between 7 mm to 8 mm long. The corolla is yellow and slightly pubescent on the outside. The paleae of the corolla are ovate-lanceolate, near 6 mm long, and 2 mm wide. The paleae of the disc are obovate, with the upper margin denticulate, near 3 mm long and 2 mm wide (León, 1964).
The fruit is achene, purple when immature and dark brown or black when mature. Seed formation is very rare. Even when produced, a high percentage of the seeds are unviable or show low vigor (Grau & Rea, 1997).
Yacon develops well under both partial shadow and full sunlight. This plant species is neutral for stem and tuberous root formation. However, the formation of tuberous roots begins later in higher latitudes. Yacon is an adaptable plant species in conditions of seasonal cycles of drought and frost. Because of its growing habits, it requires humidity during the first stages, but subsequently can tolerate drought periods. Yacon has great adaptability to altitude but is commonly grown between 500 m and 2 750 m above sea level in the Andes, although yacon has also been grown at sea level both in New Zealand and Japan. Although the foliage is damaged or dies during frosts, apparently the underground tissues are not affected unless they are frozen. Yacon is known to tolerate temperatures as low as 4°C. It needs near 200 days of no-frost climate before the tuberous roots are ready for harvest. The optimal development is reached between 18°C and 25°C. The foliage can tolerate relatively high temperatures, at least 40 °C, without any symptom of damage, provided that a suitable water supply is maintained. Apparently, yacon needs low night temperatures in order to form optimal tuberous roots. The mature plants possess well-developed foliage, with a high transpiration capacity, so that they require a regular and important water supply. Yacon grows better in soils slightly retentive of humidity, with regular watering. Yacon develops well within a wide range of soil conditions; its development is favoured by deep, well-tilled soils, rich or moderately rich in organic matter and well drained. Yacon can tolerate a wide range of pH, from acid to slightly alkaline (León, 1964).
The first introduction of yacon into Europe was made in 1927 in San Remo, Italy. After 13 years of adaptation it was recommended to use yacon as a source of dietetic nutrition and as a fodder crop, but mainly as material for sugar industry (Calvino, 1940). Since Calvino's experiments yacon was introduced into Germany in 1941, in Hamburg and Wulfsdorf (Bredemann, 1943). Besides the Andes region growing yacon has also been extended to Brazil, Japan, Korea, Mexico, New Zea-land, the United States, Russia, Estonia and Taiwan. Yacon was introduced into the Czech Republic 13 years ago, where at present it is cultivated successfully, at the Czech University of Life Sciences. It registers high relative yields of biomass: up to 34 $t.ha^{-1}$ of tuberous roots, 54 $t.ha^{-1}$ above ground, 14 $t.ha^{-1}$ of fresh leaves and 2 $t.ha^{-1}$ of dry leaves.
The aim of this study was to elaborate a phenological scale of yacon on the basis of knowledge of the morphology and dynamics of growth in the climatic conditions of Central Europe. The phenological scale collects major macrophenological phases of yacon and can contribute to the determination of the optimal method of cultivation and dates of agrotechnical procedures in field conditions during the vegetation.

MATERIAL AND METHODS

Plant material

The research covered several groups coming from various climatic conditions of the world. During the experiments, four genotypes of yacon were observed coming from New Zealand (NZL, the first genotype of yacon introduced in the Czech Republic in 1993), Germany (DEU, has been grown since 1994 in the Czech Republic and was the oldest grown genotype under conditions of Central Europe), Ecuador (ECU, introduced into the Czech Republic in 1994) and Bolivia (BOL, grown in Czech Republic since 1995). Plants were cultivated in the mentioned years on trial field plots of Czech University of Life Sciences – Suchdol in barley-beet region at an altitude of 286 m above sea-level. The average temperature of all the vegetation period in the investigated years was 14.97°C and precipitation was 316.18 mm (Tab. 1). Yacon was harvested in October 2001–2004 after 149–170 days of vegetation period.

METHODS

Methods were based on the observation of yacon in the trial fields of The Czech University of Life Sciences in the period 2001-2004. The growth and developmental changes of yacon were investigated and described in the macrophenological scale according to the BBCH scale (Strauss, 1994; Pulkrábek, 1998) comprised of ten principal growth stages and their secondary growth stages. Plants were measured every fourteen days. The height of parts of the plants above the ground, number of leaf pairs, ramification of main stem, formation of stem and tuberous roots and the blossoming phase of individual plants were recorded. The start of the gro-wing phase was recorded in all cases, when 50–70% of plants in vegetation reached the given phase. During vegetation both, growth and development of above ground parts, as well as formation of tuberous roots and stem roots were investigated.

RESULTS AND DISCUSSION

On the basis of investigation of yacon growth and development during vegetation macrophenological

scale (Fig. 1) was determined.
Yacon is planted on the field after the spring frosts in the form of germinated rhizomes, when the first pair of leaves is forming on the stem. At the beginning of the vegetation stage slow growth occurred. They are little able to compete and it is necessary to thin them out once or twice. It is also useful to provide irrigation in this period. When plants have five pairs of leaves (on average after 55–60 days), the vegetation joins up. The leaf area enhances in this period and internodes begin to become longer. A specific microclimate is forming in the vegetation and the plants tolerate increased levels of drought. The increase of the above ground biomass sharply enhances and the yacon grows till the blossoming period (Graph 1). Plants begin to randomise after 60–70 days after planting. The first shoots form on the base of the stem and the plant further randomises upwards. The bottom branches are longer (1.07 m) and can reach almost the same height as the main stem (1.33 m). The upper branches are shorter (25 mm). The stems randomise along the whole length (total randomising). Generally three types of randomising occur in yacon: basal, this type occurs on the main stem, total, the branches are formed from the base of the stem to its top; and apical, when the randomising occurs in the upper third of plant (Meza, 1995). The plants have a well-developed root system after 50–60 days from planting and they begin to form new rhizomes. They also form the first tuberous roots having a mass of 6–15 g, during further vegetation growth. On one plant, even 30 tuberous roots could be formed. Some of them can have a mass of 976 g.
Blossoming (the phase at the beginning of flowering) of plants in our conditions occurs in our conditions on average after 146–150 days and in Andean conditions after 150–220 days after planting. In climatic conditions of the Czech Republic three of five of the cultivated genotypes flower (Tab. 2). As a result of selection and adaptation to new climatic conditions a larger number of plants every year flower (58.6%-NZL; 51.9%-ECU; 35.3%-BOL; in 2004). It was observed, that a correlation between the beginning of flowering and randomising of the upper most node of the stem exists. The length and course of flowering were thoroughly recorded and

Code (2-digit)	Description
	Principal growth stage 0: Sprouting
	Principal growth stage 1: Leaf development
11	formation of the first couple of leaves
13	formation of the second couple of leaves
15	formation of the third couple of leaves
17	formation of the fourth couple of leaves
19	formation of the fifth couple of leaves
	Principal growth stage 2: Ramification
21	beginning of ramification
27	ramified half of stem
29	all stem ramified
	Principal growth stage 3: Crop cover
31	Beginning of crop cover: 10% of plant meet between rows
32	20% of plant meet between rows
33	30% of plant meet between rows
34	40% of plant meet between rows
35	50% of plant meet between rows
36	60% of plant meet between rows
37	70% of plant meet between rows
38	80% of plant meet between rows
39	crop cover complete: about 90% of plant meet between rows
	Principal growth stage 4: Formation of tuberous roots
40	beginning of tuberous roots formation
41–48	formation of tuberous roots
49	maturity of tuberous roots
	Principal growth stage 5: Bud formation
	Principal growth stage 6: Flowering
61	beginning of flowering
65	Full flowering (50% of flowers in the first inflorescence)
67	70% of flowers in the first inflorescence
69	End of flowering in the first inflorescence
	Principal growth stage 7: Formation of achenes
	Principal growth stage 8: Maturity of achenes
	Principal growth stage 9: Senescence

divided into individual secondary growth stages (Tab. 2, Fig. 2). Blossoming period (from the beginning of blossoming to blossom fall) takes on average 16.5 days. After the blossom falls the matu-ration of achenes follows. Seeds obtained in our conditions are not germinative. In the Andes the produced seeds are also not germinative, perchance only a small percentage germinate (15–32%) (Chicata, 1998; Soto, 1998). In this phase the vegetation period in the conditions of Central Europe is usually finished as a result of the early autumn frosts. Despite the fact that the tuberous roots of the yacon do not reach physiological maturity (senescence, growth stage 9), it is possible to obtain high yields of a good quality. Length of the vegetation period in Czech Republic is affected by the spring and autumn frosts and ranges from 149–170 days. In the Andean regions yacon is harvested after blossoming, when the stems begins to wither away and bend. Harvest runs from 210 to 270 day after planting (Meza, 1995; Rea, 1992; Seminario, et al, 2003). For this reason it is necessary to select clones with a shorter vegetation period, which would be more usable for cultivation under the conditions of Central Europe.

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Tab. 1: Climatic data for the years 2001–2004.

Parameters	2001	2002	2003	2004	Average
Average air temperature (°C)*	14.84	15.25	15.90	13.90	14.97
Sum of precipitation (mm) *	356.00	387.02	211.49	310.20	316.18
Length of sunshine (hr) *	972.25	1002.81	1389.15	1145.70	1127.48
Vegetation period (days)	156	149	170	161	159

* values of all vegetation period

Source: Czech Hydrometeorological Institute (2001–2004); http://www.chmi.cz/meteo/ok/infklim.html

Tab. 2: Flowering (principal growth stage 6) – Secondary growth stages (according to BBCH scale)

Secondary growth stages	Genotype		
	NZL	ECU	BOL
61- Beginning of flowering (days after planting)	146.9	144.8	150.6
65- Full flowering (50% of flowers in the first inflorescence) (days)*	5.2	4.9	5.7
67- 70% of flowers open in the first inflorescence. Beginning of ♂ flower opening (days)*	0.0	1.0	0.6
69- End of flowering in the first inflorescence End of ♂ flowering (days)*	4.4	6.5	5.4
Flowering plants (%)	58.6	51.9	35.3

* number of days from the previous subphase

Graph 1: Height of plants during vegetation in 2004

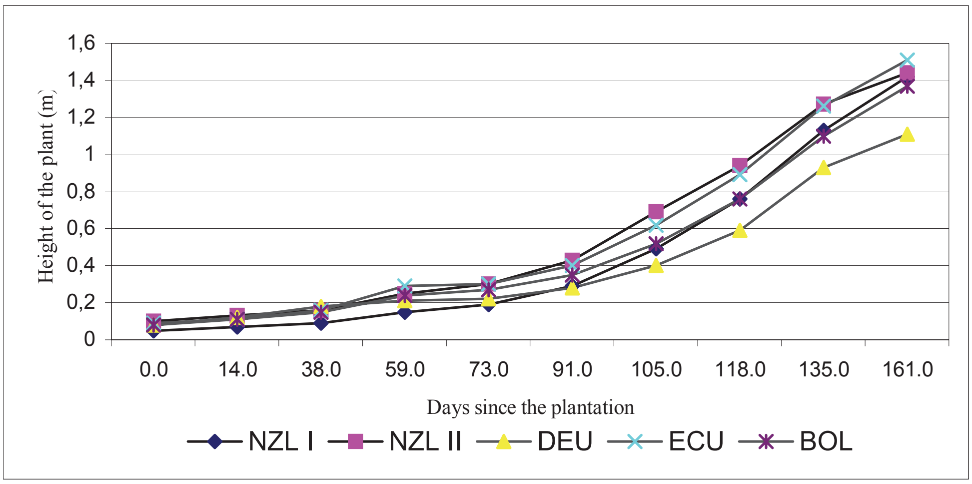


Fig. 1: Principal growth stages of yacon (according to BBCH scale)

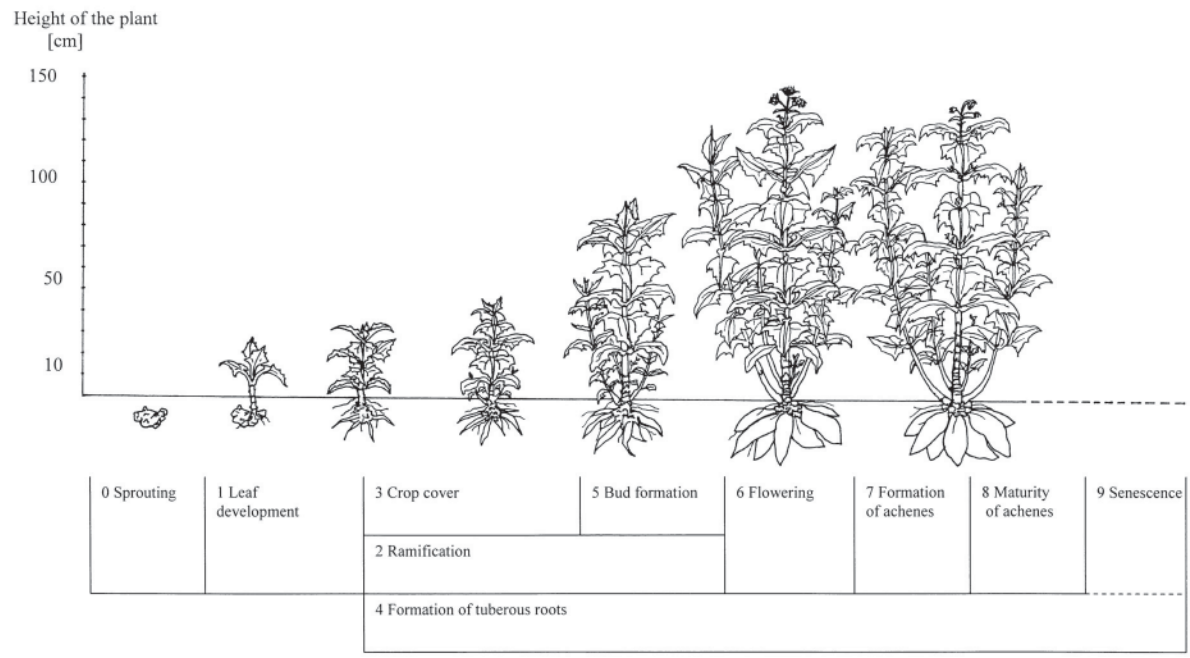
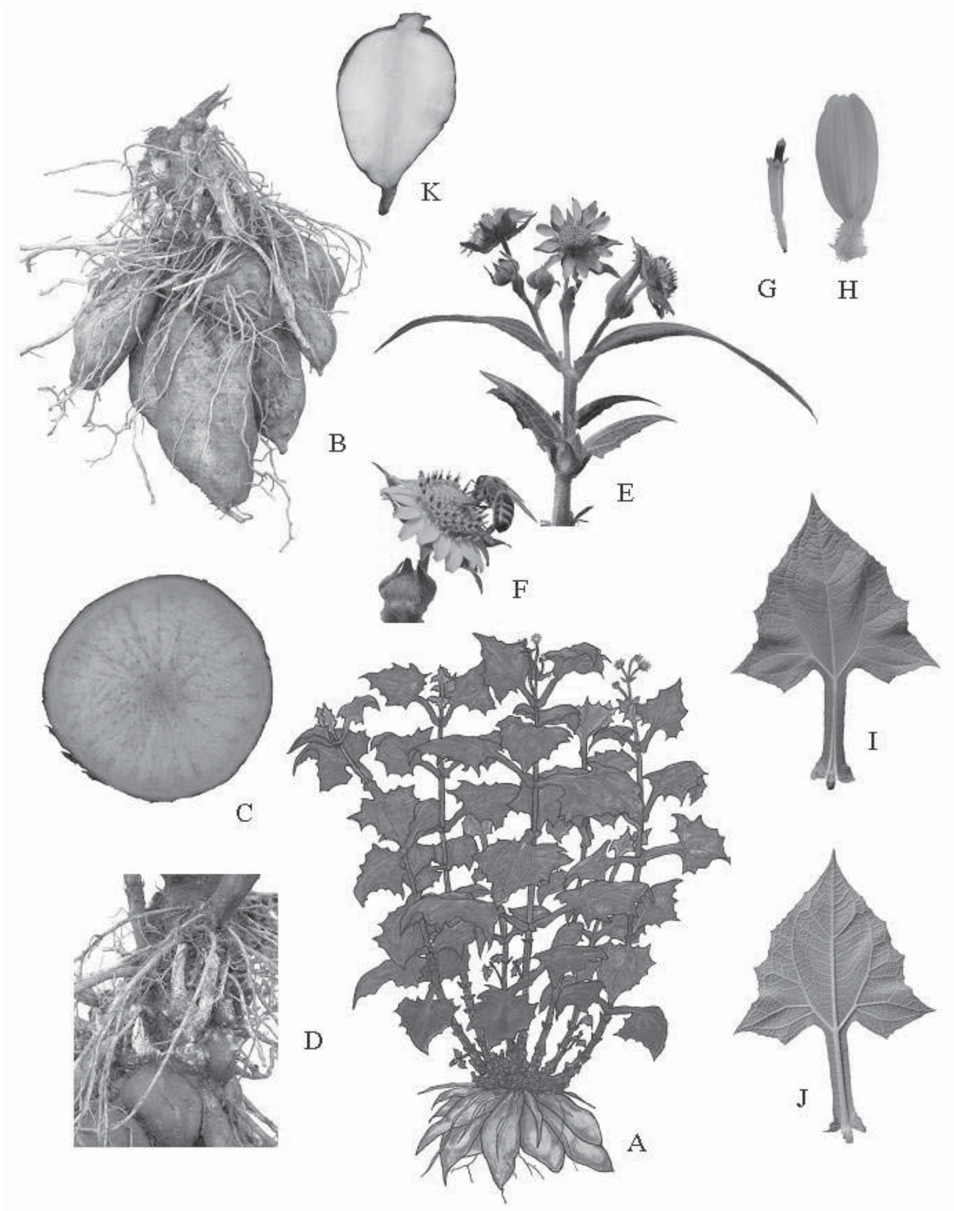


Fig. 2: Flowering (principal growth stage 6) – Secondary growth stages (according to BBCH scale)

61- Beginning of flowering, **65**- Full flowering (50% of flowers open in the first inflorescence), **67**- 70% of flowers open in the first inflorescence, **69**- End of flowering in the first inflorescence

Fig. 3: Yacon [*Smallanthus sonchifolius* (Poepp. et Endl.) H. Robinson] morphological aspects.



A: Yacon plant; B: Tuberous roots; C-K: Transverse and longitudinal section of the tuberous root; D: Rhizome; E: Flowering branches; F: Flowerhead; G: Staminate disk flower; H: Pistilate ray flower; I-J: Leaves (adaxial and abaxial leaf faces)

Corresponding author:

Assoc. Prof. Fernández E.C., Ph.D
Czech University of Life Sciences
Institute of Tropics and Subtropics
165 21 Prague 6 – Suchdol, Czech Republic
E-mail eloy@its.czu.cz

A MATHEMATICAL APPROACH: SPRINKLER IRRIGATION DROP DISTRIBUTION ON SOIL SURPACE

KARA T.

Abstract

The objectives of this study were to develop an equation and derive equation for different boundary conditions of sprinkler irrigation drop falling and to stop runoff from soil surface. Irrigation scheduling is the process related to when, how much water to apply to a soil. The Irrigation method concerns "how" that desired water depth is applied to the field. The uniformity of water distribution depends on an irrigated field and efficiency of on-farm water application. Conclusions point out on the laterals must install parallel to field slope contours for controlling runoff, erosion and on-farm water application.

Key words: mathematical; model; drop; distribution

INTRODUCTION

Irrigation scheduling requires knowledge on crop water requirements (evapotranspiration) and yield responses to water, the constraints specific to each irrigation method and irrigation equipment, the limitation relative to the water supply system and the financial and economic implications of the irrigation practice (Heermann, 1996). To improve the irrigation method requires the consideration of the factor influencing the hydraulic processes, the water infiltration and the uniformity of water application to entire field (Hlavek, 1992). The consideration of all these aspects makes irrigation management a complex decision making and field practice process (Pereira, 1999).
Sprinkler irrigation is suitable for most crops. It is also adaptable to nearly all irrigable soils, because sprinklers are available for a wide range of discharge capacities. Where soils have low water-holding capacity and shallow-rooted crops are to be irrigated, lighter and more frequent irrigations are required. Fixed and continuously moving systems are both suitable for such applications. The flexibility of present sprinkler equipment and its efficient control of water application make the method almost universally applicable. Its usefulness for most topographic conditions is subject only to limitations imposed by land use capability and economics. It can be adapted to most climatic conditions where irrigated agriculture is practical (Keller and Bliesner, 1990; Gencoglan et al., 2005).

The sprinkler irrigation method can be operated with application rate higher than the steady state infiltration rate. In general, this type of operation is implemented for stationary sprinkler systems. The sprinkler application rate will be lower that the infiltration rate immediately after irrigation commences, and all the water applied infiltrates into the soil. As time passes, the infiltration rate decreases and becomes less then the sprinkler application rate.
When irrigation continues after this point, runoff occurs (James, 1988; James and Larson, 1976), although the amount of runoff will step depend on the amount of water that can accumulate in small surface depressions and on the slope.
This paper aims at approaching mathematical models which could contribute to the achievement of higher irrigation performances when drop distributions and surface runoff on soil.

Algebraic model formulation

In this section an algebraic model formulation develop the effective drop distribution. For this reason, precipitation of drop from sprinkler nozzle and wetted area on soil must be detected well for distribution uniformity.
In sprinkler irrigation, in the wetted area drops, wetted distribution determine as a function (D(ρ)) which in symmetric to axis (Figure 1). Wetted distribution in circle shape with a r radius. If distribution boundary as given below:

$$D(\rho) = \begin{cases} f(\rho), & \rho \le r \\ 0, & \rho > r \end{cases} \qquad (1)$$

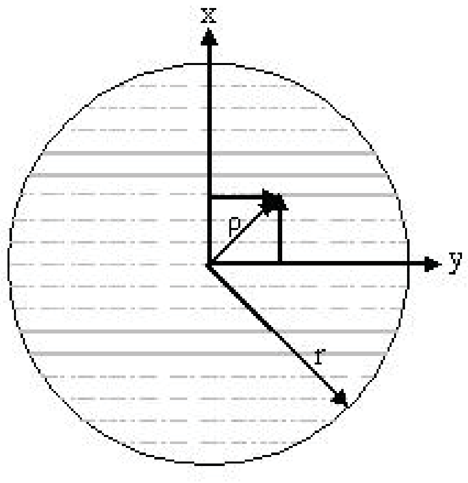


Fig.1: Under ideal condition irrigation drop distribution

Meaning, the drop from nozzle constitutes parallel and equal distance lines in wetting circle. Same of irrigation water infiltrate to soil but some of water accumulate soil surface. Accumulate water will be same quantity between two lines (band). In this case wetted distribution can be described by Eq. (2):

$$\rho(x) = \sqrt{x^2 + y^2} \qquad (2)$$

x and y is coordinates points. S(x) is the volume of water between two lines. Water volume is described by Eq. (3):

$$S(x) = 2\int_0^y D(\rho)dy = 2\int_0^y f(\rho)dy \qquad (3)$$

as it is known:

$$x^2 + y^2 = r^2 \Rightarrow y = \sqrt{r^2 - x^2} \qquad (4)$$

adding equation (4) into equation (3) resulting S(x) Eq. (5):

$$S(x) = 2\int_0^{\sqrt{r^2-x^2}} f\left(\sqrt{x^2 + y^2}\right)dy \qquad (5)$$

Band length for unit width is $\left(l = 2y = 2\sqrt{r^2 - x^2}\right)$. Since irrigation distribution (g(x)) is described by Eq.

$$g(x) = \frac{S(x)}{l} = \frac{\int_0^{\sqrt{r^2-x^2}} f\left(\sqrt{x^2 + y^2}\right)dy}{\sqrt{r^2 - x^2}} \qquad (6)$$

Irrigation distribution will work different boundary conditions. There are some scenarios to occur:

Scenario 1

Suppose that wetted drop distribution $f(\rho) = a$, g(x) is determining Eq. (7):

$$g(x) = \frac{1}{\sqrt{r^2 - x^2}} \int_0^{\sqrt{r^2-x^2}} a\,dy = \frac{a}{\sqrt{r^2 - x^2}} y\Big|_0^{\sqrt{r^2-x^2}} = \frac{a\sqrt{r^2 - x^2}}{\sqrt{r^2 - x^2}} = a \qquad (7)$$

A result shows that drop distribution is uniform.

Scenario 2

Suppose that wetted drop distribution $f\left(\rho\right)=b\rho$, g(x) determining Eq. (8):

$$g(x)=\frac{\int_0^{\sqrt{r^2-x^2}} f(\rho)dy}{\sqrt{r^2-x^2}}=\frac{1}{\sqrt{r^2-x^2}}\int_0^{\sqrt{r^2-x^2}} b\rho dy=\frac{b}{\sqrt{r^2-x^2}}\int_0^{\sqrt{r^2-x^2}}\sqrt{x^2+y^2}\,dy=$$

$$\frac{b}{\sqrt{r^2-x^2}}\left[\frac{y}{2}\sqrt{x^2+y^2}+\frac{x^2}{2}\ \ln\left(y+\sqrt{x^2+y^2}\right)\right]_0^{\sqrt{r^2-x^2}}=\frac{b}{\sqrt{r^2-x^2}}\left(\frac{r\sqrt{r^2-x^2}}{2}+\frac{x^2}{2}\ln\frac{\sqrt{r^2-x^2}+r}{x}\right)=$$

$$\frac{br}{2}+\frac{bx^2}{2\sqrt{r^2-x^2}}\ln\frac{\sqrt{r^2-x^2}+r}{x} \tag{8}$$

Scenario 3

Suppose that wetted drop distribution $f\left(\rho\right)=c\rho^2$, g(x) determining Eq. (9):

$$g(x)=\frac{1}{\sqrt{r^2-x^2}}\int_0^{\sqrt{r^2-x^2}} c\left(\sqrt{x^2+y^2}\right)^2 dy=\frac{c}{\sqrt{r^2-x^2}}\int_0^{\sqrt{r^2-x^2}}\left(x^2+y^2\right)dy=$$

$$\frac{c}{\sqrt{r^2-x^2}}\left(x^2y+\frac{y^3}{3}\right)\Big|_0^{\sqrt{r^2-x^2}}=\frac{c}{\sqrt{r^2-x^2}}\left[x^2\sqrt{r^2-x^2}+\frac{\left(\sqrt{r^2-x^2}\right)^3}{3}\right]=$$

$$\frac{c}{\sqrt{r^2-x^2}}\left[x^2\sqrt{r^2-x^2}+\frac{\left(r^2-x^2\right)\sqrt{r^2-x^2}}{3}\right]=c\left(x^2+\frac{r^2-x^2}{3}\right)=\frac{c(2x^2+r^2)}{3} \tag{9}$$

Scenario 4

Suppose that wetted drop distribution is parabolic $f\left(\rho\right)=a+b\rho+c\rho^2$, g(x) determining Eq. (10):

$$g(x)=\frac{1}{\sqrt{r^2-x^2}}\int_0^{\sqrt{r^2-x^2}}\left(a+b\rho+c\rho^2\right)dy=a+\frac{br}{2}+\frac{bx^2}{2\sqrt{r^2-x^2}}\ln\frac{\sqrt{r^2-x^2}+r}{x}+\frac{c(2x^2+r^2)}{3} \tag{10}$$

The result of Eq. (10) is meaning irrigation drops distribute as equal to soil surface.

Lets look at interaction between irrigation water and soil surface while irrigation nozzle circling (Figure 2).

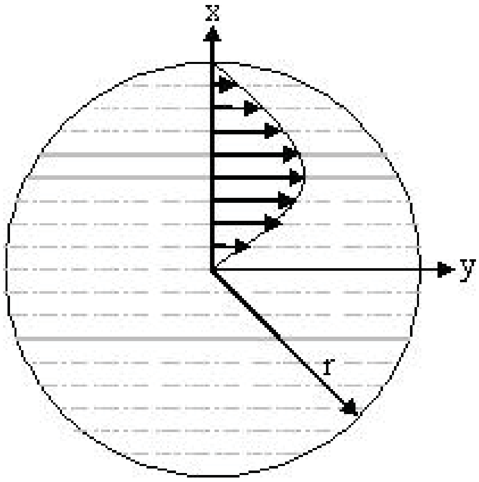


Fig. 2: Irrigation drop distribution with sprinkle nozzle moving on y axis

For this case boundary conditions given Eq. (11):

$$D(\rho) = \begin{cases} f(\rho), & \rho \geq r \\ 0, & \rho < r \end{cases} \qquad (11)$$

In this case, water source point moves from y axis. Since S(x) (volume of water) be formed small water volumes on coordinates x and y, thus can be shown as Eq. (12):

$$g_k(x) = 2\int_0^y f(\rho)\,dy = 2\int_0^{\sqrt{r^2-x^2}} f\left(\sqrt{x^2+y^2}\right)dy \qquad (12)$$

There are some other cases that in equation (11) boundary condition.

Scenario 5

Suppose that wetted drop distribution is :

$f(\rho) = a + b\rho + c\rho^2$ result is Eq. (13)

with using equation (12)

$$g_{kk}(x) = 2\int_0^{\sqrt{r^2-x^2}} \left(a + b\rho + c\rho^2\right)dy = (2a+br)\sqrt{r^2-x^2} + bx^2 \ln\frac{\sqrt{r^2-x^2}+r}{x} + \frac{(4cx^2+2cr^2)\sqrt{r^2-x^2}}{3} \qquad (13)$$

Scenario 6
Suppose starting drop distribution $D(\rho)$ as an n degree polynomial, it occurs such as $f(\rho)=\sum_{i=0}^{n} a_i \rho_i$ when we look at the first four term equation of the equation ($f(\rho)=a_0+a_1\rho+a_2\rho^2+a_3\rho^3+a_4\rho^4+\ldots$) can be written as Eq. (14, 15)). According to case results irrigation distribution function depends on x and r values.

$$g_{kp}(x)=2\int_0^{\sqrt{r^2-x^2}}\left(a_0+a_1\rho+a_2\rho^2+a_3\rho^3+a_4\rho^4+\ldots\right)dy==(2a_0+a_1r)\sqrt{r^2-x^2}+a_1x^2\ln\frac{\sqrt{r^2-x^2}+r}{x}+$$

$$\frac{(4a_2x^2+2a_2r^2)\sqrt{r^2-x^2}}{3}+2a_3\left[\frac{r(2r^2+3x^2)\sqrt{r^2-x^2}+3x^4\ln\frac{\sqrt{r^2-x^2}+r}{x}}{8}\right]+$$

$$2a_4\left[\frac{(8x^4+4x^2r^2+3r^4)\sqrt{r^2-x^2}}{15}\right]+\ldots \qquad (14)$$

or $$g_{kp}(x)=\int_0^{\sqrt{r^2-x^2}}\left(a_0+a_1\rho+a_2\rho^2+a_3\rho^3+a_4\rho^4+\ldots\right)dy=g_{kk}(x)_{a=a_0;b=a_1;c=a_2}+$$

$$2a_3\left[\frac{r(2r^2+3x^2)\sqrt{r^2-x^2}+3x^4\ln\frac{\sqrt{r^2-x^2}+r}{x}}{8}\right]+2a_4\left[\frac{(8x^4+4x^2r^2+3r^4)\sqrt{r^2-x^2}}{15}\right]+\ldots \qquad (15)$$

RESULTS AND DISCUSSIONS

The cases show that in different boundary conditions with different scenarios. When the field separates equal apart lines (band) movement of sprinkler irrigation nozzle has to be y axis. Derivations show that starting drop distribution is not dependent and irrigation distribution (g(x) = constant) is become a constant.
Irrigating in cropping season soil surface preparation and laterals must install parallel to slope contours.

CONCLUSIONS

Irrigation distribution in different boundary conditions were discussed with an algebraic model formulation, the main scenario was when infiltration becomes constant surface flow starts. As it is known infiltration does not stops but it works with surface flow together. There must be some other scenarios to get more accurate results such as field slope and precipitations (rain).
As results shows that another conclusion is that before cropping and irrigation to decrease surface flow field must till parallel to contours.

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Corresponding author:

Assoc. Prof. Dr. Tekin Kara, Ph.D.
Ondokuz Mayis University
Agricultural Faculty
55139 Kurupelit/Samsun, Turkey
tekinkar@omu.edu.tr

ASSESMENT OF FOOD ACCESSIBILITY IN THE BIE PROVINCE (ANGOLA)

MAZANCOVÁ J., NOVÁK M., KREPL V.

Abstract

Angola belongs to the countries with a very high rate of prevalence of undernourished population (FAO, 1999). The study assesses a food accessibility of randomly selected respondents in Kuito and communities nearby in the Bie Province. Various reasons contributing to the current situation related to access to food and the rate of influence of food inaccessibility on people's life quality are discussed. The majority of surveyed households are engaged in agricultural activities. More than half of the households cover their food consumption needs from own production, which cannot offer well-balanced diet and make people more vulnerable.

Key words: food accessibility, Angola, people's vulnerability.

INTRODUCTION

Food problem is one of many consequences of the long-lasting war. Regions most affected by long and heavy fights together with the enormous forced migration of population and troops of soldiers are slowly recuperating from economic and social destruction. Agriculture has been deeply influenced by the war consequences. Casualties, disability, loss of schooling, savings, livestock, seed and tools have lead to the current unsatisfactory situation of agriculture. Even though the climate is generally favourable for crop cultivation the soils tend to be of low fertility. Agriculture in the Bie Province is still dependent on the external assistance, especially in terms of knowledge, skills and agricultural inputs supply. 70% of population (MINADER, 2006) is involved in agriculture or related activities. Food insecurity, a low level of health care, HIV/AIDS prevalence and limited agricultural possibilities increase people's vulnerability.

Food accessibility is only one aspect of the food security. Food security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life. Household food security is then the application of this concept at the family level, with individuals within households at the focus of concern. Physical unavailability of food, population's lack of social or economic access to adequate food and inadequate food utilization form the framework of food insecurity (FIVIMS).

Objective

The objective of this study consists in an assessment of food accessibility of randomly selected respondents in Kuito and communities nearby in the Bie Province. Accessibility of basic food items, preferences in food consumption and rate of influence of inaccessibility of some food items on population were studied. Results could serve as a source in decision making process related to future agricultural activities.

MATERIAL AND METHODS

The survey process contains of following parts:
1. analysis of secondary data
2. training in using methods of Rapid Rural Appraisal and participatory methods to collect and understand information from the selected target group
3. fieldwork in different areas. Data collection and direct analysis within the whole team. The fieldwork was executed in June–December 2006. To gather information there were used the following tools: focus group discussion on agricultural production, individual household visits and interviews and structured and semi-structured questionnaires. As the survey languages were used Portuguese and Umbundu.
4. analysis – final organization of collected data, writing summaries, discussions at the regular meetings.

The study was covered by *Centro de Educação Agrário da Província do Bié (CEAB)/Center of Agricultural Education in the Bie Province* established within the Czech Development Cooperation.

The survey sample is formed by 100 respondents. 55% (55) of respondents live in a city (Kuito) or in its suburb, 45% (45) then in countryside areas. It can be stated that in the survey sample, the urban and suburban population is represented balanced in relation with the total amount of Angolan population living in urban area (53%) (World Bank, 2005). Kuito is a capital of the Bie province. The estimated population of Kuito munici-pality counts approximately 500 000. The estimation of city population is not known.

RESULTS AND DISCUSSION

Household characterization

Angolans belong to a collectivist society (Hofstede, 1991). The consistency of larger family is their nature but also a need coming from the local conditions. Only 3.3 % of respondents live alone. In contrary, the absolute majority of respondents share a household with more family members. 22.4% of respondents stated that their households share five family members, 19% share a household with six more people (7 family members) and 13.8% with five more people (6 family members). 29.3% then live with more than seven family members in a household. The remaining respondents (15.5%) form families of four or less members.
The typical respondent is more likely a town-dweller living in a household of five members.

Food production

A majority of Angolan population is directly linked with agricultural activities. One of the sections of the survey was focused on the gathering information about respondents' relation to land tenure and their running activities related to land. 28.8% of the respondents consider themselves as the farmers working on their own land, 8.5% of the respondents represent the farmers working on land of someone else. 75% of the respondents did not provide sufficient information about this problematic. As a possible explanation could be regarded the fact that land property relations have not been clearly determined so far.
Even though more than a half of surveyed sample represent urban population, 81% of the respondents stated that they have cultivated various crop plants or participate in food production in other way. Only 19% of the respondents are not engaged in agricultural activities. These results indicate that low-income households solve problematic of food supply with their own production.
71.4% from the 19% of the respondents which are not engaged in agricultural activities admitted that at least one member of their household participates in food production through agriculture. These results support a significance of agriculture for livelihood strategies of local households.
The most commonly cultivated crops are maize and beans cultivated in a consortium (98% of the respondents) and cassava. Other crops and their cultivation by the respondents are given in a Figure 1.

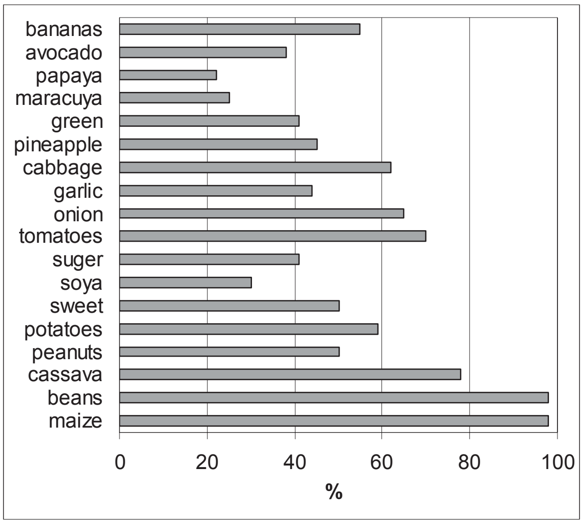

Fig. 1: Percentage expression of cultivation of various crops

The main identified purpose of sugar cane cultivation a distilled beverage production (*caxi*). *Caxi* production belongs to the significant income generation activities at a household level. On the other hand *caxi* production highly contributes to the overall problem of alcoholism.
Livestock production is rare. 11.2% of the respondents keep poultry and only 2% keep goats and pigs. Beef cattle are scarce and only used for animal traction.

Management of food products

The term of food product involves fresh food as well as processed food products (dried products, flour, beverages). 25% of the respondents keep the complete agricultural products for their own consumption while 34.1% of the respondents sell smaller part of their products and bigger keep for themselves. A half of products is kept by 36.4% of the respondents. None of the respondents sells a complete production.

At the local markets 55% of the respondents sell a higher amount of their food products, 30.8% smaller amount of their food products and 17.5% do not sell there.
Selling the higher amount of their products to retailer is used by 17.9% of the respondents, 30.8% of the respondents sell in this way smaller amount of their production and 51.3% of the respondents do not use this way.
Exchange of own products with the neighborhood is selected by 53.8% of the respondents for smaller amount of their production. Exchange of smaller amount of own products with other vendors at markets is practiced by 41% of the respondents.

Less accessible and not accessible food

The following list presents such basic food which the respondents consider for whatever cause as less accessible or not accessible at all. The most frequent food items belonging to this group are as follows: oil, sugar, salt, eggs, meat, rice, wheat, vegetables.
The reasons of this inaccessibility and rate of influence on people's life quality according to the respondents are shown in Figure 2. The respondents identified the following reasons of inaccessibility of selected food items:

1) these food items are too expensive

Food is relatively expensive in the Bie Province and hence people opt for such food items which make them feel full. The preferences of food choice related to nutritive content were not reported. Basic awareness of food security and food safety as well as information about food and health interaction is still insufficient, especially in isolated rural areas. Meat belongs to the group of the most expensive food items. Its insufficiency at the markets is caused by very a low or absent livestock production as a consequence of the long-lasting war. More than half of the respondents admitted a very high influence rate of food price on their quality of life.

2) these food items are not at markets in a sufficient amount

Insufficient amount of the food items listed above is mainly caused by still "emergency" approach to agricultural systems even if it was recognized that transition from emergency to development process should have been initiated earlier (Whiteside, 2005). Low crop diversity, lack of seeds of good quality, low level of agricultural knowledge, lack of tools represent only the most obvious causes of the current situation. Despite the high agricultural potential of the Bie Province, only few crops are cultivated. Wheat and rice as most demanded by the respondents are still missing on the fields. Recognition of this situation by the Ministry of Agriculture and Rural Development of Angola, a call for rehabilitation of wheat and rice cultivation and their post-harvest processing was implemented among other recommendations submitted at XXVIII Consultative Council of MINADER in 2006. As the Figure 2 shows the respondents percept the insufficient supply of the given food items as significant.

3) to gain these food items is difficult due to a distance of markets

Very weak transport infrastructure is the main constraint to market opportunities. The poor conditions of the

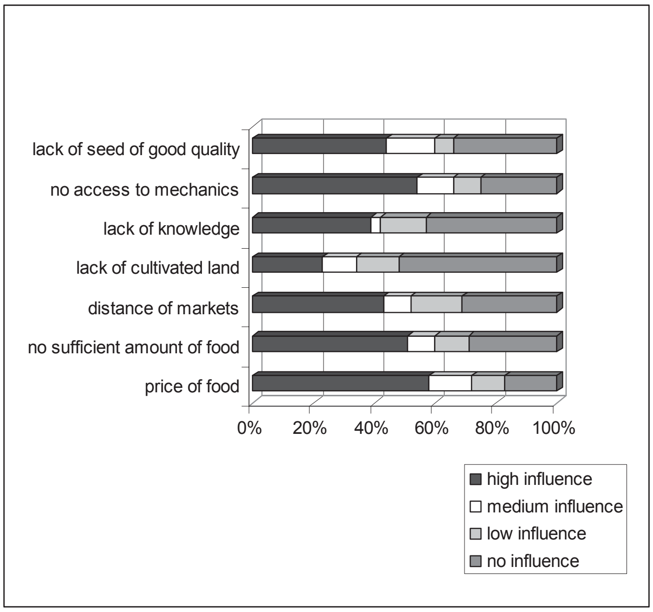

Fig. 2: Rate of influence of various reasons of food inaccessibility on people's life quality

[1] Available on-line from: www.minader.org/eventos/xxviiconselhoconsultivo(2006).ht

road and non-functioning of the railway cause most of the high transition costs at markets. Access to the main roads from isolated community is a major problem. Tertiary roads and farmers' ability to buy bicycles and ox-carts can be considered as limitation factors. Distance of an urban market is usually one or two days of walk which significantly increases vulnerability of walking women (assault, rape).

4) the respondents cannot produce the food items by themselves because of lack of cultivated land
According to the results shown in Figure 2, the respondents do not consider lack of cultivated land as a significant constraint of food production. This fact is in accordance with the results of the survey lead by Norfolk (Norfolk, 2004) which reported that almost all families had recognized access and tenure over more land than they were presently able to cultivate. In most cases this was land, in addition to areas of fallow land that had never been cleared or cultivated (i.e., virgin bush land).

5) the respondents cannot produce the food items by themselves even if they have a land they do not know how to produce them
Knowledge of good practices of soil preparation, crop cultivation and crop rotation seem to be at average level among the Bie population. Rural population knows the basic practices related to cultivation of maize, beans, manioc, peanuts, and potatoes. The knowledge of cultivation and post-harvest processing of former cash crops as coffee and sisal are kept only by elder people. Transfer of agricultural information was interrupted during the war period and its rehabilitation is in the initial phase fully supported by MINADER or NGOs. By interviewing the rural youth it was reported that they approve only very limited recognition of knowledge of the generation of their parents.
Knowledge related to soil protection and utilization of organic residues is very rare and seems to be as a consequence of Portuguese agricultural practices in Bie. In terms of knowledge and skills realizing in livestock production the situation is even worse. In the war period livestock was the first part of agriculture hardly damaged. Cattle almost disappeared from the Bie province and nowadays it suffers its rehabilitation only with the support of MINADER and NGOs' distribution programmes.
As it is obvious from the Figure 2, less than 40% of the respondents assume that with better knowledge they could improve their access to hardly accessible food items. On the other hand, more than 40% do not assume so.

6) the respondents cannot produce food items them-selves because even if they have a land and knowledge related to cultivation they do not have access to mechanics of good quality
The level of mechanization of agriculture is low mainly because of unavailability and high prices of agricultural machines and its implements. Most of the agricultural operations are practiced within hand-tool technology, only small part as draught-animal technology.

7) the respondents cannot produce the food items (especially crop and vegetable production) because of no access to seed of good quality
Access to seed of good quality is very low. Currently there run several programmes of seed distribution supported by MINADER and NGOs – CARE International and Africare. However, the results are not very satisfactory since the main obstacle is seen in a low and not complex technical support, even in the NGOs' distribution programmes. Apart this, seed of good quality at markets are beyond rural population's financial means. In the majority of cases the peasants produce seed themselves. In practice it means putting aside a part of the production; store it to the next sowing. There are identified two crucial factors influencing the yield of this seed. First, seed is smaller, with a low germinative capacity and often damaged. Secondly, during storage time losses can achieve even more than 50% of stored amount. The causes mainly consist in fungal, mould and pests attack.

CONCLUSION

The majority of the surveyed households are engaged in agricultural and related activities. Variability of food production is limited and do not offer a well-balanced diet to local population. A low accessibility or an inaccessibility of certain food items is above all caused low inputs in agriculture and limited market oppor-tunities. As a consequence, insecure food supply situation do not only lower people's life quality but in addition it can cause the adoption of risk behaviour increasing so people's overall vulnerability.

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Corresponding author:

Ing. Jana Mazancová
Czech University of Life Sciences Prague,
Institute of Tropics and Subtropics
165 21 Prague 6, Czech Republic
mazan@its.czu.cz

TILLAGE PRACTICES AND EFFECT OF SOWING METHODS ON GROWTH AND YIELD OF MAIZE CROP

MEMON S.Q., MIRZA B. BAIG, MARI G.R.

Abstract

An experiment was carried out at Latif Experimental Farm, Sindh Agriculture University, Tando Jam during 2004, in order to assess the effect of tillage on soil physical properties growth and yield of maize under different sowing methods. The maize variety Akbar was planted on clay loam soil under three different methods ridge, drilling and broadcasting using RCBD. It was found that soil moisture content was higher in ridge sowing method as compared to other sowing methods. While bulk density and soil strength were relatively lower in ridge sowing plots as compared to seed drill and seed broadcasting plots. The results of agronomic observations revealed that plant height, number of leaves/plant, number of cobs/plant, dry cob weight, seed index, root length and total grain yield/ha were superior in ridge sowing, the second best was seed drilling, while seed broadcasting was found to be less effective. Maize sown on ridges resulted in greater seed emergence 89%, plant height 155.1 cm, weight of hulled dry cob 177.67 g, de-hulled dry cob 127.53 g and seed index 198.26 g, which in turn caused greater grain yield 6.35 t/ha, the next best was seed drilling, while seed broadcasting was not effective as other two methods.

Key words: tillage practices, sowing methods, emergence, growth, yield, maize

INTRODUCTION

Many developing countries strive for an increase of their agriculture production in order to feed the rapidly growing population. Contrary to many other countries, Pakistan still has the possibility to expand the cultivated area since there is no lack of suitable land. Maize is most important cereal crop of the world, it is used for three main purposes as human food, feed for poultry and livestock. Maize being the highest yielding cereal crop in the world is of significant importance, where rapidly increasing population has already out stripped the available food supplies to use for direct human consumption, the other major outlets are the wet-milling industry and livestock feed. The maize crop categorized as cereal having starch in the grain, production of starch is the major objective of wet-milling industry, the production of maize oil is then very dependent on the demand for the starch component. Thousands of years recorded history, groups of human being have been tilling in order to increase the production of food, tillage includes any physical manipulation of soil, usually done in preparation for same aspect of crops production. The most favorable crop production requires a suitable soil condition, while the suitable soil condition can be obtained by best tillage practices. Kapner (1982) defined the tillage as the mechanical manipulation of soil, the goal of proper tillage is to provide a suitable environment for seed germination, weed control, excess moisture removed and reduction of surface runoff by increasing infiltration. The degree of soil compaction, soil bulk density and soil moisture condition are important factors that influence seedling emergence and crop yield.

The tillage equipment may cause soil compaction and upset the balance between the air and water components of soil, the compaction cause due to tillage implements may increase the soil strength and restrict root growth. However, a slight compaction is needed to gain good contact between seed and soil particles. This can be achieved by well planed tillage practices that can provide means for creating congenial soil environment, which is particularly necessary for seed germination and effective plant growth. Frequent traffic of machinery and equipment, in irrigated field cause a breakdown of soil structure in the topsoil layer, and considerable compaction of the lower layers. As a result, it is difficult to prepare a good seedbed, germination is affected, and irregular stands are obtained.

MATERIAL AND METHODS

The study was conducted at Latif Experimental Farm, Sindh Agriculture University, Tando Jam, during 2004. The experimental area is located at distance of about ½ km in north of Sindh Agriculture University, Tando Jam. The soil at the site was medium textured clay loam, it has an average bulk density of 1.21 g/cm^3, retains 19.45% moisture. The experiment was laid out in a Randomized Complete Block Design with three treatments, each replicated three times for the study, the treatment consisted of T-1 (Ridge sowing method), T-2 (drilling sowing method), T-3 (Broadcasting method). Seedbed was prepared according to the treatments. Ridges were prepared by ridger, keeping 75 cm distance between ridge to ridge, while for seed drilling the plots were leveled by using leveler, for broadcasting the plots were remained ploughed. Homogenous seeds of a maize variety Akbar were dibbled into ridges at a 5 cm depth, while for drilling row to row distance was 75 cm, however, broadcasting was done manually seed rate was 50 kg/ha, the recommended doze of fertilizer was applied (Khoso, 1998). In each treatment the agronomic observations were recorded, plants were selected randomly from each plot and tagged.

Physical Properties of Soil
Soil samples were taken at the depths of 0-15 cm, 15-30 cm and 30-45 cm, respectively. The soil samples were collected in polyethylene bags and soil moisture content, bulk density and soil texture were analyzed.

Soil moisture content
Soil moisture content on dry weight basis was determined randomly, the soil samples were taken from the test plots, at a depth of (0–15, 15–30, 30–45,) cm, the electrical balance was used for measuring the soil samples. The samples were placed in oven at 105^0C for 24 hours. The dried soil samples were re-weighed in an electrical balance and the weight was recorded. The soil moisture percent (% dry weight basis) was calculated using the following formula, RNAM, (1995).

$$MC = \frac{Ww - Ww}{Wd} \times 100$$

Where

MC =	Moisture content	(%)
Ww =	Weight of wet soil	(g)
Wd =	Weight of dry soil	(g)

Soil texture (by hydrometer methods)
Soil samples were collected and dried into open air, the dispersion cups were filled 1/3 with water and 10 ml of $1N.Na_2Co_3$ were added to the cup. The material was dispersed for 5–10 minutes with the help of dispersion machine. Reading with hydrometer was taken after two hours and 40 seconds, then the percent clay, silt and sand were calculated as follows, RNAM (1995).

$$\%\ \text{Clay} + \text{Silt} = \frac{1^{st}\ \text{correct reading}}{\text{Wt of soil sample}} \times 100$$

$$\%\ \text{Clay} = \frac{2^{st}\ \text{correct reading}}{\text{Wt of soil sample}} \times 100$$

% Silt = (% Clay + % Silt) – % Clay

% Sand = 100 – (% Clay + % Silt)

Bulk density of the soil
The measurement of soil bulk density (g/cm^3), soil sample were randomly taken at a depth of (0–15, 15–30, 30–45,) cm, from the main test plot. The diameter of core sampler was measured with venire caliper. The samples were dried in a hot air oven at 105^0C and dry weight of soil sample was recorded. The bulk density of soil was determined by using the following formula, RNAM (1995).

$$\infty = M/V$$

$$V = \frac{\pi}{4} D^2 L$$

$$\infty = \frac{4M}{3.142\ D^2 L}$$

Where

∞ =	soil bulk density	(g/cm^3)
M =	Dry soil mass in a core sampler	(g)
V =	volume of cylindrical core sampler	(cm^3)
D =	diameter of cylindrical core sampler	(cm)
L =	length of cylindrical core sampler	(cm)

Soil aggregation
Soil aggregation was evaluated by using a set of sieves. This methods is called the sieve analysis, the set of six sieves were selected for determining the degree of soil aggregates with mesh of 75 mm, 50 mm, 37.5 mm, 25 mm, 12.5 mm, 8 mm. The soil aggregations were determined randomly placing half square meter frame over ploughed area. The soil samples were gently passed through a set of above sieves, passed through the smallest aperture sieve and were retained on the next sieve and were passed through the smallest aperture sieve, following formula was used to determine the soil aggregation, RNAM (1995).

$$\text{Mean Soil Clod Diameter} = \frac{\sum WD}{\sum W}$$

Where
Σ W = sum of weight of soil clods or weight of soil held by a particular sieve kg.
D = Equivalent diameter of clods or size of sieve (mm).

Soil compaction
Soil strength is the ability or capacity of a particular condition to resist or endure an applied force. Penetration resistance is a composite parameter that involves several independent properties of a soil but it is generally considered to reflect the strength of the soil. To measure penetration resistance, a simple instrumented probe known as a pentrometer was used to observe the relation to penetration depth Kapner (1982).

Tillage implements
The implement used in the present research study was moldboard plough, Tandem disc harrow, seed driller and Ridger. All the implements were standard field machines powered by MF-375 diesel tractor. The instruments and other materials used in the research study were steel tape, stop watch, meter scale, soil sampler, soil containers, electric oven, electric balance,

soil cone penetrometer, graduated cylinder, jericon, range poles, camera and chalks. The specifications of the tillage implements used in research study were as follows.

Specification s of tillage machines

Implements	Specifications
Mould board Plough	3 bottom mounted, general purpose mould board, extension of mould board 21.5 cm, width of plow 120 cm and vertical clearance 68 cm.
Tandem disc harrow	Tandem disc harrow having 2 gangue, each gangue contain 8 disc, dia of rear gangue 60 cm, front gangue 42 cm, vertical clearance 43 cm.
Seed drill	A tractor driven manual operated corn planter five seed planting tubes, depth of sowing 10 cm, tine to tine spacing 75 cm.
Ridger	The ridger was used for earthen up the crop sown in rows. 3-ridge mounted, maximum row spacing 71.1 cm, overall width 117.8 cm, depth 105.0 cm, clearance (under frame) 55.0 cm.

Emergence percentage
For seed emergence/ square meter was used to calculate the emergence percentage and number of plants were counted, and emergence %age was calculated from each replication according to the formula,

$$\text{Emergence \% age} = \frac{\text{No. of seed emergence}}{\text{No. of seed sowing}} \times 100$$

Number of leaves/Plant
Square meter was used to count the number of leaves per plant in each replication. The plants were randomly selected in each replication and number of leaves per plant was counted and their average was workout.

Plant height
Plant height was recorded from randomly selected plants in each treatment with measuring scale from soil surface to the tip of the plant in cm and their average was workout.

Number of cob/plant
Square meter was used to count the number of cob per plant in each replication. Number of cob per plant produced by each replication was selected and counted their mean values were calculated.

Cob length (cm)
Square meter was used to measure the length of cob per plant in each replication. At harvest cob length was recorded from each replication-selected plant with the help of measuring tap and their average was tabulated in centimeters.

Cob weight (g)
Maize cob from each selected plant at harvest was air-dried and their weight was obtained by using electrical balance in grams.

1000 maize grain weight (g)
A harvest maize cob collected from each plots was air dried and threshed separately then a samples 1000 grains from each treatments was obtained and their weight was recorded by using electrical balance.

Maize grain yield (t/ha)
After threshing of cobs from each plot was weight through electrical balance and tabulated as grain yield/ha by using the following formula

$$\text{Grain yield/ha} = \frac{\text{Grain yield/treatment}}{\text{Area/treatment}} \times \text{Area/ha}$$

Root length
Root length reading were taken at harvest of maize crop, it was measured in centimeters from the base of the stem to the tip of the root. Soil was dugged to proper depth and cut deep block of the soil from five different locations in each plot. The block with plant was soaked in water for 24 hours, root was separated carefully from adhering organic matter and soil particles, and five plants were selected from each plot to determine root length.

RESULTS

Soil Texture

The analysis of experimental soil at various depths 0–15, 15–30 and 30–45 cm recoded. It was observed that the soil was clay-to-clay loam. At 0–15 cm, the textural class was clay with 30.5% sand, 24.1% silt and 45.8% clay. While at 15–30 cm the textural class was the same, while at 30–45 cm soil depth the texture was changed clay to clay loam with 32.6% sand, 31.6% silt and 35.8% clay, shown in Table 1.

Soil moisture content, under different sowing methods

Soil moisture content at 0–15 cm depth as shown in the Table 2. The mean soil moisture content before tillage operation was 19.44 percent. The average soil moisture content after each irrigation all treatments was recorded (19.23, –20.68 percent. There was significant difference in all treatments. The average soil moisture content at 15–30 cm depth and 30–45 cm depth are shown in Table 2, and Table 2 there was significant difference in all treatments.

Tab.1: Soil texture at 0–45 cm depth

Soil depth (cm)	Sand (%)	***Silt*** (%)	Clay (%)	Textural class
0–15	30.5	24.1	45.8	Clay
15–30	22.6	36.6	40.8	Clay
30–45	32.6	31.6	35.8	Clay loam

Tab. 2: Soil moisture content 0-15 cm depth after each irrigation

Treatments	Before Till lager	Number of irrigations				
		1st Ir 01-08-04	2nd Ir 25-08-04	3rd ir 15-09-04	4th Ir 30-09-04	Mean (%)
T-1	19.44	20.59	20.65	20.73	20.74	20.68
T-2	19.43	19.61	19.62	19.66	19.68	19.64
T-3	19.44	19.13	19.21	19.27	19.30	19.23
Mean (%)	19.44					

Soil moisture contents 15–30 cm depth after each irrigation.

Treatments	Before Tillage	Number of irrigation				
		1st Ir 01-08-04	2nd Ir 25-08-04	3rd ir 15-09-04	4th Ir 30-09-04	Mean (%)
T-1	19.45	19.40	19.35	19.28	20.47	19.869
T-2	19.46	19.73	19.60	19.51	20.10	19.70
T-3	19.45	19.83	19.74	19.66	19.90	19.59
Mean (%)	19.45					

Soil moisture content 30–45 cm depth after each irrigation

Treatments	Before Tillage	Number of irrigations				
		1st Ir 01-08-04	2nd Ir 25-08-04	3rd ir 15-09-04	4th Ir 30-09-04	Mean (%)
T-1	19.48	20.02	19.90	19.85	20.47	20.21
T-2	19.49	20.15	19.98	19.89	20.23	20.04
T-3	19.48	20.21	20.05	20.10	20.10	19.93
Mean (%)	19.48					

Ir = irrigation

	Treatments	Intervals
S.E	0.0298	0.0344
Cd1	0.0730	0.0843
Cd2	0.111	0.1276

Bulk density of the soil, under different sowing methods

The bulk density of the soil at 0–15 cm depth was shown in the Table 3. The average mean bulk density before tillage operation recorded that 1.21 g/cm^3, there was significant difference in all treatments. While the bulk density of the soil after tillage operation in all the treatments it was ranged from 1.13, 1.14 and 1.15 g/cm^3. There was highly significant difference in all treatments. The bulk density of the soil at 15–30 cm depth was shown in the Table 3. The average mean bulk density before tillage operation recorded that 1.22 g/cm^3, while the bulk density of the soil after tillage operation in all the treatments it was varied from 1.15, 1.19 g/cm^3. There was highly significant difference in treatments. The bulk density of the soil at 30–45 cm depth was shown in the Table 3.The average mean bulk density before tillage operation recorded that 1.22 g/cm^3, while the bulk density of the soil after tillage operation in treatments were from 1.22–1.22 g/cm^3. There was no-significant difference in all treatments.

Soil compaction, under different sowing methods
The soil compaction at 0–45 cm depth was shown in the Table 4. The mean soil compaction before tillage operation was recorded, there was significant difference in all treatments. While soil compaction after tillage operation in all treatments was recorded. There was highly significant difference in all treatments.

Plant Analysis

Emergence of maize seedling
The emergence of maize seedling shown in Table 5. The results revealed that the differences in the emergence of seedlings between three methods of sowing were highly significant. Maize sown on ridges resulted in greater emergence of seedling (89%), followed by drilling the seed (85%) , while seed broadcasting resulted in a lower emergence of seedlings (83%). The greater emergence of seedlings on ridge sowing was due to well pulverization of soil resulting easier appearance of the seedling than drilling or broadcast of seed.

Plant height
The average plant height of maize crop recorded at various intervals under different method of planting as shown in Table 6, it reveal that after 15 days of sowing it was greater under ridge sowing (20.4 cm/plant) followed by seed drilling (20.2 cm/plant) while it was lowest incase of seed broadcasting (18.5 cm/plant). After 30 days 40.2, 39.6 and 34.1 cm/plant, after 45 days of sowing 89.8, 89.4 and 90.3 cm/plant, after 60 days 124.7, 118.5 and 119.10 cm/plant, after 75 days 138.5, 137.8 and 135.2 cm/plant, while after 97 days (at harvest time) it was 155.1, 152.3 and 151.1 cm/plant in ridge, drilling and seed broadcasting methods. The above results demonstrate that ridge sowing displayed greater plant height as compared to drilling and broadcasting methods.

Root length (cm)
The results on root length of maize recorded at harvest shown in Table 7. It may be seen from the results that varied significantly between the treatments. Maize sown on ridges resulted in greater of root length (33.1 cm/plant), followed by seed drilling (29.5 cm/plant), while seed broadcasting resulted in lower length of root (27.20 cm/plant). The statistical analysis of the data showed a significant ($P \leq 0.01$) change in the length of root between the treatments.

Number of leaves/plant
The results on number of leaves/plant of maize planted under three different methods of sowing shown in the Table 8. The results revealed that number of leaves recorded after 15 days of sowing remained same in all three treatments, while they change after 30 days of sowing up to harvest. Maize sown on ridges produced greater number of leaves 7, 10, 14, 15.3 and 17/plant after 30, 45, 60, 75 and 97 days of sowing respectively, while seed drilling or seed broadcasting resulted in more or less similar number of leaves/plant. The results further demonstrate that the differences between drilling and broadcasting are non significant.

Tab. 3: Bulk density 0–15 cm depth after each irrigation

Treatments	Before Tillage	Number of irrigations				
		1st Ir 01-08-04	2nd Ir 25-08-04	3rd ir 15-09-04	4th Ir 30-09-04	Mean g/cm^3
T-1	1.20	1.08	1.10	1.16	1.17	1.13
T-2	1.21	1.09	1.11	1.16	1.16	1.14
T-3	1.21	1.09	1.12	1.17	1.17	1.15
Mean g/cm^3	1.21					

Bulk density 15–30 cm depth after each irrigation

Treatments	Before Tillage	Number of irrigations				
		1st Ir 01-08-04	2nd Ir 25-08-04	3rd ir 15-09-04	4th Ir 30-09-04	Mean g/cm^3
T-1	1.21	1.11	1.14	1.16	1.20	1.15
T-2	1.21	1.14	1.19	1.21	1.22	1.19
T-3	1.22	1.13	1.18	1.21	1.22	1.19
Mean g/cm^3	1.22					

Bulk density 30-45 cm depth after each irrigation

Treatments	Before Tillage	Number of irrigations				
		1st Ir 01-08-04	2nd Ir 25-08-04	3rd ir 15-09-04	4th Ir 30-09-04	Mean g/cm³
T-1	1.22	1.22	1.22	1.22	1.22	1.22
T-2	1.22	1.22	1.22	1.22	1.22	1.22
T-3	1.22	1.22	1.22	1.22	1.22	1.22
Mean g/cm³	1.22					

Ir = irrigation

	Treatments	Intervals
S.E	5.2526	6.0653
Cd1	12.8689	14.8599
Cd2	-	22.5023

Tab. 4: Soil compaction 0–15cm depth

Treatments	Before Tillage	After Tillage				
		1st Ir 01-08-04	2nd Ir 25-08-04	3rd ir 15-09-04	4th Ir 30-09-04	Mean KN/m²
T-1	962	506	655	820	960	735
T-2	967	530	690	860	955	761
T-3	967	532	687	859	964	761
Mean KN/m²	965					

Soil compaction 15–30cm depth

Treatments	Before Tillage	After Tillage				
		1st Ir 01-08-04	2nd Ir 25-08-04	3rd ir 15-09-04	4th Ir 30-09-04	Mean KN/m²
T-1	1036	635	855	1020	1145	914
T-2	1037	640	860	1023	1146	917
T-3	1040	641	861	1024	1146	918
Mean KN/m²	1038					

Soil compaction 30–45cm depth

Treatments	Before Tillage	After Tillage				
		1st Ir 01-08-04	2nd Ir 25-08-04	3rd ir 15-09-04	4th Ir 30-09-04	Mean KN/m²
T-1	1142	1142	1142	1142	1142	1142
T-2	1142	1142	1142	1142	1142	1142
T-3	1142	1142	1142	1142	1142	1142
Mean KN/m²	1142					

Ir = irrigation

	Treatments	Intervals
S.E	0.6293	0.7765
Cd1	1.5419	1.9024
Cd2	2.335	2.881

Tab. 5: Average emergence of maize under different sowing methods

Sowing methods	R-I	R-II	R-III	Mean (%)
Ridge	87	89	91	89 a
Seed drill	84	86	85	85 b
Broadcast	84	83	82	83 b

S.E. = 0.913
Cd1 = 2.920
Cd2 = 4.196

Tab. 6: Average plant height of maize under different sowing methods

Replication	Plant height (cm) days after sowing.					
	15	30	45	60	75	97 (at harvest)
Ridge						
I	20.9	40	90.3	120.8	137.9	156.2
II	20.4	39	89.6	125.9	138.2	154.3
II	19.9	41.6	89.7	127.6	139.6	154.8
Average	20.4	40.2	89.8	124.7	138.5	155.1 a
Seed drill						
I	20.1	36.7	89.3	119.2	136.2	152.2
II	19.8	41.3	89.3	119.6	140.1	152.2
II	20.7	41.0	89.6	116.7	137.2	153.1
Average	20.2	39.6	89.4	118.5	137.8	152.5 b
Broadcast						
I	19.1	33.0	90.0	119.3	135.3	151.2
II	18.5	34.4	90.1	118.3	134.2	150.0
II	17.9	35.0	91.0	119.8	136.1	152.3
Average	18.5	34.1	90.3	119.1	135.2	151.1 c

S.E = 0.456
Cd1 = 1.459
Cd2 = 2.096

Tab. 7: Average root length under different sowing methods

Sowing methods	R-I	R-II	R-III	Mean (cm)
Ridge	34.6	32.2	32.6	33.1 a
Seed drill	30.1	29.6	28.8	29.5 b
Broadcast	29.2	24.8	27.7	27.2 b

S.E. = 0.645
Cd1 = 2.064
Cd2 = 2.965

Tab. 8: Average number of leaves/plant, under different sowing methods

Replication	Number of leaves days after sowing.					
	15	30	45	60	75	97 (at harvest)
Ridge						
I	4	7	10	14	15	18
II	4	7	10	14	16	16
II	4	7	10	14	15	17
Average	4	7	10	14	15.3	17
Seed drill						
I	4	6	9	13	14	15
II	4	6	9	13	14	16
II	4	6	9	14	13	15
Average	4	6	9	13.3	13.6	15.3
Broadcast						
I	4	6	9	13	14	16
II	4	6	10	13	13	16
II	4	6	9	13	14	15
Average	4	6	9.3	13	13.6	15.6

S.E. = 0.471

Length of cob hulled and de-hulled

Table 9 shows the results on average length of cobs hulled of maize planted under three different sowing methods recorded, the results showed that length of cobs did not differ significantly between the treatments. Maize sown on ridge produced maximum length of cob (24.40 cm), followed by seed drilling (20.5 cm), while seed broadcasting resulted in minimum length of cob (19.40 cm/plant). The results on average length of cob de-hulled shown in Table 9. It can be seen from the results that length of cob de-hulled also did not differ significantly between the treatments. It was found that ridge sown crop produced greater cob length de-hulled (21.5 cm), followed by drilling (17.8 cm), while seed broadcasting resulted in lesser cob length (16.6 cm/plant).

Tab. 9: Average cob length hulled, after 97 days (at harvesting)

Sowing methods	R-I	R-II	R-III	Mean (cm)
Ridge	23.2	26.0	24.0	24.4
Seed drill	22.4	18.9	20.3	20.5
Broadcast	20.1	23.0	15.3	19.4

Average cob length de-hulled

Sowing methods	R-I	R-II	R-III	Mean (cm)
Ridge	20.2	23.1	21.2	21.5
Seed drill	19.8	16.2	17.5	17.8
Broadcast	18.3	19.3	12.4	16.6

S.E. = 1.494

Dry weight of cob (hulled / de-hulled)

The results on mean dry weight of cob hulled / de-hulled shown in the Table 10. It may be seen from the results that dry weight of cob both hulled and de-hulled varied significantly between the treatments. In hulled ridge sowing produced maximum weight of dry cob (177.67 g/cob), followed by seed drilling (172.77 g/cob), while seed broadcasting produced minimum dry weight of cob (167.12 g/cob). In case of de-hulled ridge sowing produced maximum weight of dry cob (127.53 g/cob), followed by drilling (123.43 g/cob), while broadcasting showed lowest weight of dry cob (122.32 g/cob) on de-hulled basis.

Tab. 10: Average hulled dry cob

Sowing methods	R-I	R-II	R-III	Mean (g)
Ridge	178.06	176.16	178.79	177.67 a
Seed drill	171.21	172.11	174.91	172.77 ab
Broadcast	166.64	169.65	165.09	167.12 b

Average de-hulled dry cob weight

Sowing methods	R-I	R-II	R-III	Mean (g)
Ridge	127.06	126.16	129.39	127.53 a
Seed drill	125.21	123.11	121.99	123.43 ab
Broadcast	123.64	122.22	121.10	122.32 b

S.E. = 0.938
Cd1 = 3.001 Cd2 = 4.311

Seed index (1000 grain weight) gram

Table 11 shows the results of mean seed index it may be seen from the results that seed index differed significantly between the treatments. Maize sown on ridges produced greater seed index value (198.26 g), followed by seed drilling (193.04 g), where as; seed broadcasting produced lower seed index value (183.26 g).

Maize grain yield

The results on average maize grain yield/ha tabulated on the basis of grain yield/treatments shown in Table 12. It revealed that grain yield differed significantly between the treatments at one percent level of probability. Maize sown on ridges gave maximum grain yield 6357 kg/ha (6.3 t/ha), followed by seed drilling 5834 kg/ha (5.8 t/ha), while seed broadcasting gave minimum grain yield 4887 kg/ha (4.8 t/ha).

Economic analysis

The results on economic analysis of various methods in maize planting shown in Table 13, reveal that maize sown on ridges, seed drilling and seed broadcasting incurred Rs. 15 817.29/ha, Rs. 15 779.79/ha and Rs. 15 416.54/ha on total cost of production, respectively. Where as total gross return was Rs. 81 051.75/ha, from production of 6357 kg/ha, Rs. 74 383.50/ha from production of 5834 kg/ha and Rs. 62 309.25/ha from production of 4887 kg/ha at the rate of Rs.12.75/kg in case of ridges, drilling and broadcasting, respectively. Thus, ridge planting gave a healthy net return of Rs. 65 234.46/ha, followed by seed drilling Rs. 58 603.71/ha and seed broadcasting Rs. 46 892.71/ha. These results clearly demonstrate that maize sown on ridge gave an additional income of Rs. 6630.75 against seed drilling and Rs. 11 711.00 against seed broadcasting on per hectare basis.

Tab. 11: Average 1000 dry maize grain weight

Sowing methods	R-I	R-II	R-III	Mean (g)
Ridge	196.30	200.15	198.35	198.26
Seed drill	193.34	190.80	195.00	193.04
Broadcast	183.48	178.90	187.40	183.26

S.E. = 1.626
Cd1 = 5.204
Cd2 = 7.476

Tab. 12: Average grain yield t/ha, under different sowing methods

Sowing methods	R-I	R-II	R-III	Mean (kg/ha)	(t/ha)
Ridge	6361	6429	6283	6357	6.35
Seed drill	5859	5816	5829	5834	5.83
Broadcast	4978	4811	4873	4887	4.88

S.E. = 38.793
Cd1 = 124.100
Cd2 = 178.300

Tab. 13: Economic analysis of different methods of sowing

Cost	Sowing methods		
	Ridge	Drilling	Broadcasting
1. Fuel consumption (Rs.)	1719.363	1685.27	1355.04
2. Lubricant at 10% of diesel cost (Rs.)	171.93	168.52	135.50
3. Labour cost			
Skilled 3 No. @Rs.200/hrX4-hr Watch man 1No. @ Rs. 1800/M x 3	2400.00	2400.00	2400.00
4. Inputs	5400.00	5400.00	5400.00
Seed at 50kg/ha (Rs.)			
DAP 2.5 bags (60kg/ha) @Rs.1000/bag	687.00	687.00	687.00
Urea 125 kN/ha (4.5bags) @Rs.480/bag	2139.00	2139.00	2139.00
5. Tractor hired @ Rs.200/hr for 4-hrs	800.00	800.00	800.00
6. Total cost of production (a) (Rs.)	15 817.29	15 779.79	15 416.54
Return			
1. Yield t/ha	6.357	5.834	4.887
2. Gross income/h (b) sell @ Rs.12.75/kg	81 051.75	74 383.50	62 309.25
3. Net income/h (b – a) (Rs.)	65 234.46	58 603.71	46 892.71

DISCUSSION

Appropriate method of sowing has several advantages like better inter-culturing, weeding, uniform irrigation, management of insect, pest and disease and mechanical harvesting. Ridge sowing is considered to be the method which have the above advantages, against the other methods of sowing like drilling and broadcasting of seed, although seed drilling is also an appropriate method of sowing to have some less advantages in contrast to ridge sowing in the modern agriculture farming.

Ridge cultivation is originally developed for preparing seed bed in field that were to be irrigated by furrow irrigation, it was found however, that the method has merits which are quite independent of the irrigation system. The furrow between the ridge provides efficient drainage during the rainy periods, in early spring the ridge dried more rapidly and the soil warmed up sooner, than in land cultivated on the flat in the conventional manner. All the unfavorable effects of the compaction following tillage operations remained confined to the furrow between the ridge as a result, only one quarter, approximately of the field was adversely affected, whilst roots found favorable conditions in the remaining three quarters, in which soil structure was well preserved and ensured favorable conditions of aeration and moisture.

The results of the present study revealed that the experimental soil was clay-to-clay loam, soil moisture content at 0–15 cm depth the mean soil moisture content before tillage operation was 19.44 percent. The soil moisture content after tillage operation in all treatments ranged from 19.23–20.68 percent. There was highly significant difference in all treatments. Soil moisture content at 15–30 cm depth, the mean soil moisture content before tillage operation was found to be 19.45 percent. The soil moisture content after tillage operation in all treatments varied from 19.59–19.86 percent. There was non- significant difference in all treatments. Soil moisture content at 30–45 cm depth, the mean soil moisture content before tillage operation was observed 19.48 percent. The soil moisture content after tillage operation in all treatments ranged from 19.93–20.21 percent. There was highly significant difference in all treatments. The result of moisture content shows that soil moisture content was conserved more in ridge plot as compared to other treatments, it is conducted that soil inverted by moldboard plough plus disc harrow plus ridger is more suitable for the conservation of high soil moisture content. The reason may be that in ridge plot more water holding capacity due to high looseness of soil particles. The present result is supported by Gyurioza *et al.* (1999), that ridge tillage the moisture content greater than in the ploughed treatment.

The bulk density of the soil at 0–15 cm depth the mean bulk density before tillage operation recorded that 1.21 g/cm^3, there was significant difference in all treatments while the bulk density of the soil after tillage operation in all the treatments it was ranged from 1.13–1.15 g/cm^3. There was highly significant difference in all treatments. The bulk density of the soil at 15–30 cm depth, the mean bulk density before tillage operation recorded that 1.22 g/cm^3, while the bulk density of the soil after tillage operation in all the treatments it was varied from 1.15–1.19 g/cm^3. There was highly significant difference in all treatments. The bulk density of the soil at 30–45 cm depth the mean bulk density before tillage operation recorded that 1.22 g/cm^3, while the bulk density of the soil after tillage operation in all the treatments it was ranged from 1.22–1.22 g/cm^3. There was non- significant difference in all treatments.

However, with moldboard operation the soil aggre-gation was 24.30, 24.29 and 24.74 mm in all plots. Si-milarly, incase of disc harrow operation the soil aggregation was 19.50, 19.62 and 19.37 mm, in all three treatment plots were prepared, however, when ridger was operated the soil aggregation was 17.76, while seed driller displayed 17.94 mm. Results further indicated that the soil compaction at 0–15 cm depth the mean soil compaction before tillage operation recorded that 965 KN/m^2, there was significant difference in all treatments. While soil compaction after tillage operation in all treatments was ranged 735–761 KN/m^2. There was highly significant difference in all treatments. The soil compaction at 15–30 cm depth, the mean soil compaction before tillage operation recorded that 1038 KN/m^2 while soil com-paction after tillage operation in all treatments was varied from 914–918 KN/m^2. There was significant difference in all treatments. The soil compaction at 30–45 cm depth the mean soil compaction before tillage operation recorded that 1142 KN/m^2 while soil compaction after tillage operation in all treatments was ranged 1142–1142 KN/m^2. There was non- significant difference in all treatments.

The results on plant analysis revealed that maize sown on ridges produced greater emergence of seedlings (89%), similarly plant height recorded after 15, 30, 45, 60, 75 and 97 days after sowing was greater incase of ridge sowing. Number of leaves/ plant recorded after 15, 30, 45, 60, 75 and 97 days of sowing was more in ridge sowing. Ridge sowing also produced greater number of cobs/plant, after 55 and 97 days length of hulled and de-hulled cob, hulled and de-hulled dry cob weight, 1000 maize grain weight, grain yield/ha and root length at maturity 33.1, 29.5 and 27.2 cm, ridge, seed drilling and seed broadcasting methods, respectively.

The results on economic analysis depicted that maize sown on ridge gave a net return Rs. 65 234.46/ha, which further displayed an additional income of Rs. 6630.75 /ha, against drill sowing and Rs. 11 711.00/ha against seed broadcasting, respectively.

The present results are supported by the findings of Vogal *et al.* (1994) found that grain yield of maize was higher with tied ridging plots. While Vedove *et al.* (1996) found that grain yield of maize was greater with ridging which was attributed to the greater amount of available N under this system.

Gyurioza *et al.* (1999) evaluated ridge tillage cultivation system for maize soybean and sugar beet, they found significant differences in the moisture content in direct sowing and ridge tillage the moisture content of 0–10 cm layer in the inter rows was 3.5–5.6% greater than in the ploughed treatment and in other parts of the ridge (sides and top of the ridge). A similar and inverse trend was observed for the temperatures. There were no substantial differences in the yield in the first year with over 11 t/ha in all treatments.

Musambasi *et al.* (2003) reported that maize planting on ridges gave the highest grain yield (5197kg/ha) during the 1995–96 season.

CONCLUSION

Appropriate method of sowing has several advantages like better inter-culturing, uniform irrigation, management of insect, pest and disease and mechanical harvesting, ridge sowing is considered to be the method which have the above advantages, against the other methods of sowing like drilling and broadcasting of seed, although seed drilling is also a appropriate method of sowing to have some less advantages in contrast to ridge sowing in the modern agriculture farming. On the basis of present study, it may be concluded that planting maize on ridge found to be more profitable as compared to seed drilling and seed broadcasting respectively.

Recommendations

Maize variety no doubt, has assured increased production yet this is being grown on limited scale in the province of Sindh. This is because of the fact that any systematic income and resulting net profit gain has never been placed before the farmers, so as to attract them to bring more area under maize. In order to give an insight in to the profitability of maize production, the present study was under taken. It is suggested that for getting healthy return from maize farming, sowing should be made on ridges as this method has several advantages.

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Corresponding authors

Prof. Dr. Mirza B. Baig
Department of Agricultural Sciences
Allama Iqbal Open University
H- 8, ISLAMABAD, PAKISTAN
mbaig95@yahoo.ca

THE ROLE OF MANPOWER IN THE SUCCESS OF IRAN'S POULTRY GROWERS COOPERATIVES

RAMEZANI M., AMINI A. M., RAISSI G. A.

Abstract

This paper strives to study the role of manpower in the success of Iran's poultry growers cooperatives. The empirical study covers 713 members, managers and board presidents. The results show that Iran's poultry growers cooperatives were not able to achieve their planned objectives. According to the findings of this study, the level of training, member participation in the cooperative, technical skills of the board presidents and managers, and knowledge of cooperative principles were low in the cases studied. The results of path analysis showed that managers' knowledge of cooperative principles, strong adherence to cooperative principles, member participation in the cooperative, technical skills of board presidents and managers, selection criteria for the managers, quality and quantity of training programs, and level of education are positively correlated with the success of agricultural cooperatives. The most important obstacle limiting the success of poultry growers cooperatives is exploitation of cooperatives for personal interests.

Key words: agricultural cooperatives, manpower, success of cooperatives

INTRODUCTION

The human element is regarded as the designer and cause of changes in a firm. In other words, man is considered to be the unparalleled capital in cooperatives (Shahbazi, 2006). The socio-economic development of a nation depends on its production capacity. The two important factors that play a crucial role in shaping this production capacity are physical resources and labor. Investment in labor is the cause and the indispensable element of development and evolution of the physical resources (Shirani, 1989). A glance at human economic thought reveals that the founders of different economic theories or schools as well as their subscribers have placed great emphasis on the role of labor in development programs. The theory maintaining that investment in manpower brings about economic growth goes back to Adam Smith and the classical economists (Amini et al., 2002). Today, most economists consider workforce as the most important factor involved in production and consider raw materials, capital, and natural resources as only subordinate to the human element. Man gathers and concentrates his assets, uses natural resources, and establishes social, economic, and political institutions to contribute to national development. Countries incapable of enhancing their labor's skills and know-how, and those failing to exploit these resources effectively towards their national economy will fail in their development plans (Shahbazi, 2006).

Today, labor management is of crucial importance in the process of development and due to the complex issues raised in this field, achieving development goals requires concerted efforts by many individuals (Shirani, 1989). Along these lines, companies have come to be regarded as frameworks for cooperation of individuals and it has been established that such institutions play an effective role in development. Success of such institutions greatly draws upon the skills of the workforce involved. This paper is an attempt to study the role of manpower in the success of agricultural cooperatives. First, we will investigate the factors involved in the success or failure of cooperatives, and we will finally present a practical model for increasing the productivity of cooperatives. Specific objectives of the present research are as follows:

1. Evaluating the success of Iran's poultry growers cooperatives in terms of achieving their predetermined objectives;
2. Identifying the knowledge and skills of cooperative members and investigating the effect(s) of member quality on the success of Iran's poultry growers cooperatives;
3. Identifying the role of managers in the firm and its relevant impacts;
4. Developing practical approaches and models for lifting the barriers limiting the success of Iran's poultry growers cooperatives.

The results from the studies by Aghajani Varzaneh (2001), Amini and Safari Shali (2002), Amini and Ramezani (2006 a & b), Darvishinia (2000), Sar Sakhti Erqui (1995) and Safari Shali (2001), that evaluated the performance of agricultural cooperatives and the factors involved, reveal that such cooperatives are generally unsuccessful. Based on these studies, members' understanding of cooperation, knowledge of cooperative principles, participation in the cooperative activities, and members' training have had a significantly positive role in increasing the efficiency and improving upon the performance of cooperatives. Erqui (1995) emphasizes that the levels of income, literacy, type of previous job, and concept of managers about authority affect their performance while such individual factors as management experience and manager's age have no bearing.

John et al. (2001) evaluated three principles of minimum profit & better services, freedom of membership, and observance of equity fairness amongst the important factors affecting the success of cooperatives. Carlo et al. (2000) identified individualistic morale, lack of member participation, poor management, irresponsibility of members, financial problems, lack of information about the members, non-ethical issues, lack of understanding of cooperative principles, weaknesses in rules and regulations, and inefficiency in competition with other firms as the limiting factors in the success of agricultural cooperatives. Bhuyan (2000) mentioned lack of understanding of cooperation on the part of members, high levels of executive expenditures, inequality in paying attention to members' interests, high expectations of members from cooperatives, and lack of powerful managers as the main barriers hindering the development of agricultural cooperatives. Results released by Australian Organization of Agriculture Studies show that the level of member participation in the cooperative has a direct relation with success of cooperatives. On the other hand, level of member participation in the cooperative is related to the level of understanding of cooperation principles, amount of social activities, influence of the members, impartiality of cooperatives, and level of satisfaction of the cooperative members and employees (AAC, 1988).

MATERIALS AND METHODOLOGY

pose of this survey research is to study the role of manpower in the success of Iran's poultry growers cooperatives. This article is concerned with the "management by objective approach (MBO)" to evaluate the performance of agricultural cooperatives (Khamoushi, 2003). This evaluation is a complex task that must be undertaken by the company members and managers. Cluster sampling has been used for this purpose. The sample consists of 50 cooperatives from 10 provinces of the originally 28 provinces. A lues-tionnaire was developed and used to collect data from agricultural cooperative managers, members, and accountants concerning various aspects of the cooperative environment.

Due to the limited statistical population of managers, we decided to include views by all executive managers and board members in our survey but as some were not available or denied to participate in the survey, we were left with only 153 managers, accounting for only 67% of the statistical population, whose views could be used in this survey.

Cochran's formula was applied at a reliability level of 0.95, probability of $q = 0.5$, and an accuracy level of $d = 0.04$ to determine the sample size needed. Then, the sample size was adjusted using the Yeats correction factor (Cochran, 1976). From 183 agricultural cooperatives with 19 216 members, 50 cooperatives and 502 members were selected. The multi-layer sampling approach was used in the selection of companies and members (Jolliffe, 1986).

Data was collected through observations, interviews, and statistical surveys. Three questionnaires were designed and used to collect data from agricultural cooperative managers, members, and accountants. Also a model was developed to relate the various characteristics of the manpower as the independent variables affecting the success of agricultural cooperatives, which was designated as the dependent variable. Each section of the questionnaire comprising a number of questions was used to evaluate one aspect of the cooperative environment. Cronbach's Alpha and KMO coefficients wee used to assess the consistency and reliability of the questionnaires (Sarmad et al., 2000). Table 1 presents the results.

Tab. 1: Internal consistency & reliability of the questionnaire used

Concepts	Number of Questions		Reliability		Consistency	
	Members	Managers	Members	Managers	Members	Managers
Member participation in the cooperative affairs	6	7	0.5085	0.8279	0.602	0.824
Technical skills of managers	5	3	0.7988	0.7665	0.694	0.681
Interpersonal skills of managers	3	–	0.7215	–	0.500	–
Training	3	3	0.8525	0.6122	0.825	0.500
Level of Success	17	17	0.6805	0.8505	0.800	0.787

A high level of internal consistency and reliability was obtained for the questionnaires used in this study.
A number of the questions were administered using the Analytic Hierarchy Process (AHP). For this purpose, the weights of questions were calculated using the factor analysis method after normalization. Then, the score of each question was multiplied by its weight. Finally, the index was determined through adding all the scores (Diakoulaki et al., 1995).
In this study, some of the various causes reported in the literature for the success of poultry growers cooperation were combined in a backward regression analysis to determine if the proposed behavioral causes could be empirically verified. The level of success of the cooperatives was the dependent variable in the regression analysis while the independent variables affect the success of poultry growers cooperatives.

RESULTS & FINDINGS

In the section, we will first introduce the method and procedure used for measuring the dependent variable (success level of the cooperatives under study), then the results from investigation of the independent variables will be discussed and, finally, the relations between the dependent and independent variables will be established through route analysis test.

A) Studying the level of success of poultry growers cooperatives

As a first step, the achievement of the cooperatives' objectives as declared in their Statutes and Constitution was evaluated as a dependent variable. Members and managers were asked to express their views on the five streams examined including procurement of production supplies required by members, market regulation, provision of consultancy, economic, and educational services. The obtained results are shown in Table (2).

Tab. 2: Evaluating the services offered to members

	Providing production supplies		**Market regulation**		**Consultancy**		**Economic services**		**Training**	
	No	Per	No	Per	No	Per	No	Per	No	Per
Poor/Very poor	448	68.4	566	84.4	538	82.1	527	80.5	476	72.7
Fair	180	27.5	73	11.2	75	11.5	105	16	135	20.6
Good/Excellent	27	4.1	16	2.4	42	6.4	33	3.5	44	6.7
Total	**655**	**100**	**655**	**100**	**655**	**100**	**655**	**100**	**655**	**100**

Based on the data in Table 2, the majority of members and managers considered the performance of the cooperatives in those fields as poor and very poor with only a minority finding it good or very good. The level of success of the agricultural cooperatives was assessed using the overall weight of the above factors. The weight results are given in Table 3.

Tab. 3: Evaluating the success of poultry growers cooperatives

Level of Success	**Members**		**Board of Directors**		**Managers**		**Total**	
	No	Per	No	Per	No	Per	No	Per
Low/Very low	450	89.6	72	63.2	26	66.7	548	83.7
Moderate	47	9.4	38	33.3	11	28.2	96	14.7
High & Very High	5	1	4	3.5	2	5.1	11	1.6
Total	**502**	**100**	**114**	**100**	**39**	**100**	**655**	**100**

Based on the data in Table 3, 83.7% of the members and managers considered the success of cooperatives in achieving their objectives to be low or very low. Since level of success of cooperatives relies heavily on the performance of managers, it seems that managers have been performing loosely and irresponsibly; the majority of members and managers assessed cooperatives as unsuccessful. Results of the mean comparison test showed that such firms have mostly concentrated on providing deposits for the members. Members and managers considered the educational, economic and consultancy services as well as market regulation by their cooperatives to be very poor. Using the cluster test, poultry growers cooperatives are categorized into five groups according to their success level. The results are presented in Table 4.

Tab. 4. : Categories of cooperatives according to the their success

Categories	Number of cooperatives in the category	Per %	Mean
A	4	8	65.19
B	13	26	51.47
C	18	36	47.42
D	9	18	37.92
E	6	12	28.75

Based on this test, 8% of the cooperatives studied, including cooperatives in Tehran Province, Shahreray, Tehran and suburbs, and Kashan, enjoyed a higher level of success compared to those in other regions. Around 12% of the cooperatives including Sia cooperatives of Assad-Abad, Babolsar and the suburbs, Khomeinishahr, Rasan of Hamedan, and Nahavand were considered very poor in terms of success level.

B) Independent variables in the poultry growers cooperatives

Having evaluated the success level of cooperatives, determinants of the dependent variable were studied. In the forthcoming paragraphs, first the independent variables will be described followed by a discussion of their influence on the success of Iran's poultry growers cooperatives. Finally, the results will be presented in Table (5).

Tab. 5: Frequency distribution of independent variables

Major Concepts	Evaluation	Members		Board of Directors		Managers		Total	
		No	Per	No	Per	No	Per	No	Per
Education	**Illiterate**	23	4.6	8	7	0	0	31	4.7
	Elementary & Guidance School	193	38.3	30	26.3	3	7.7	226	34.5
	High School & High-School Diploma	209	14.6	55	48.2	19	48.7	283	43.2
	Vocational Diploma & BS	70	14	16	14	14	35.9	100	15.3
	MS & Higher	8	1.5	5	4.4	2	5.1	15	2.3
Understanding cooperative principles	None	232	46.2	49	43	19	48.7	300	45.8
	Poor	198	39.4	30	26.3	12	30.8	240	36.6
	Mediocre	55	11	28	24.6	6	15.4	89	13.6
	High	17	3.4	7	6.1	2	5.1	26	4
Member participation in the cooperative affairs	Low or Very Low	131	26.1	14	12.2	4	10.3	149	22.7
	Mediocre	280	55.8	59	51.8	17	43.6	356	54.4
	High & Very High	91	18.1	41	36	18	46.1	150	22.9
Technical Skills of Managers *	Low or Very Low	98	19.5	14	12.3	9	23.1	121	18.5
	Moderate	244	48.6	53	46.5	11	28.2	308	47
	High & Very High	160	31.9	47	41.2	19	48.7	226	34.5
Interpersonal Skills of Managers	Poor or Very Poor	75	14.9	-	-	-	-	-	-
	Moderate	228	45.4	-	-	-	-	-	-
	High & Very High	199	39.6	-	-	-	-	-	-
Training	No training received	271	54	84	73.7	30	76.9	385	58.8
	Training received	231	46	30	26.3	9	23.1	270	41.2
Training Quality	Poor or Very Poor	65	28.2	-	-	-	-	65	24.1
	Fair	77	33.3	4	13.3	2	22.2	83	30.7
	High & Very High	89	38.5	26	86.7	7	77.8	122	45.2

* Technical skills of the managers have been evaluated from the member's point of view

The statistical tests reported in Table 5 show that a strong correlation between the said independent variables and the success of a cooperative is statistically significant at 99% level. Characteristically, poultry growers are not highly educated, although their business requires specialization in their field. Also, the comparison test showed that managers, compared to members, were better educated; in other words, their level of education was a significant factor in their election as managers.

Overall, 45.8% of members and managers had no understanding of cooperative principles while 36.6% of them were considered to have a poor understanding. Managers as compared to members had a better knowledge of cooperative principles; however, the level of knowledge of cooperative principles among both members and managers was very poor.

Members and managers considered the level of participation in the cooperative's affairs and technical skills of managers as mediocre. Generally, managers considered the level of member participation in the cooperative affairs to be higher than themselves. The members evaluated the managers in terms of their interpersonal skills. Based on the results obtained, members assessed managerial skills of the managers as high or very high.

The results showed that generally 54% of members and 73.7% of managers had received no education at all. In evaluating educational background, special weight has been given to managers. Educated individuals were asked to evaluate the quality of the training courses offered. On the whole, 24.1% of members and managers considered the quality of training offered as poor or very poor, 30.7% as fair, and 45.2% as good or very good. Satisfaction of members of the course quality was less than that of managers, which calls for consideration.

Profitability of cooperatives for members, managers and other organizations was evaluated as one of the factors affecting success of cooperatives from the viewpoint of both members and managers. The results are presented in Table (6).

Tab. 6: Frequency distribution of profitability for members, managers, and other parties

Profitability for:	Members		Managers		Organizations	
	Num	Per	Num	Per	Num	Per
Low or Very Low	32	4.9	10	1.5	15	2.3
Moderate	111	16.9	104	15.9	124	18.9
High & Very High	39	78.2	541	82.6	114	78.8
Total	512	100	655	100	516	100

The results indicate that 78.2%, 82.6%, and 78.8% of the three respondent groups considered the benefits of the cooperatives for the members, managers and other state organizations to be high or very high while 4.6%, 1.5% and 2.3% in each category considered it to be low or very low. The rest considered the benefits to be moderate.

C) Investigation of the relationships between independent variables and cooperatives' success

To study the effects of independent variables on the success of poultry growers cooperatives (the dependent variable), the path analysis and multivariate regression technique were employed. The independent variables that could theoretically affect the dependent variable were tested in the model, and their relationships with the success of agricultural cooperatives were studied. In the subsequent phases, the relationship between the intermediate independent variables and the other factors was studied so that the direct and indirect impacts of the effective variables could be evaluated. The results are presented in Table (7).

Tab. 7: Multivariate regression of determinants of cooperatives success

Dependent Variable	Success	Understanding	Participation	Technical Skills	Interpersonal Skills
Managerial & technical criteria used in electing managers	2.631**	-	-	0.414***	-
Relevant interpersonal criteria used in electing managers	0.890*	-	-	-	0.079**
Managers' technical skills	5.767***	-	1.097**	-	-
Managers' interpersonal skills	2.883*	-	0.362***	-	-
Training programs	3.182***	-	-	-	-
Number of training courses offered	1.418**	-	-	-	-
Understanding of cooperative principles	4.028***	-	--	-	-
Member participation in the cooperative affairs	1.249**	-	-	-	-
Using cooperatives for personal interests	-1.883**	-	-	-	-
Duration of membership		0.223***	0.985***	-	-
Informal education		0.175***	-	-	-
Age (Experience)		0.096*	-	-	0.367**
Constant	18.274**	0.485***	15.448***	26.431***	9.812***
R	0.671	0.408	0.541	0.146	0.163
R^2	0.451	0.166	0.292	0.021	0.026
F	42.68***	21.568***	21.568***	1.881***	4.072***

*, ** & *** Significant at 90%, 95% & 99%, respectively

In the first column of Table 7, those variables are presented that directly affect the goal variable. The Fisher's coefficient was at a reliability level of 99%, and indicates a completely significant relation holding between the remaining independent variables and the dependent one.

Taken together, the remaining variables in the model explain much of the variation observed in the success levels of poultry growers cooperatives, with a significance rate of 99%. The correlation coefficient (R = 0.671) shows a rather strong correlation between the independent and dependent variables. The coefficient of determination $R^2 = 0.451$ as well states the moderate variance of the dependent variable which is explained by the independent variables introduced into the model. Technical skills of the managers, knowledge and understanding of cooperative principles, training programs, interpersonal skills of the managers, observance of managerial criteria in electing managers, number of training courses offered, member participation in cooperative's affairs, and observance of interpersonal criteria in electing managers had positive effects on the success of poultry growers cooperatives in the proposed model. Also, managers' exploitation of the cooperative for personal interests was recognized as the most important barrier against the success of cooperatives.

The test results summarized in Table 7 show that each of the intermediate factors is in turn affected by some other variable. In this study, we have evaluated the effect of each factor on the above variables. Understanding of cooperative principles depends on the level of education and membership duration in the cooperative. Those members with a long record of membership enjoy a higher level of understanding. Informal training had no effect on members understanding of the principles from which it can be concluded that the training programs offered were not of high quality. Member's age was also effective in their understanding of the principles, which could be attributed to the experience of older members. Member participation in the cooperative affairs can be affected by interpersonal and technical skills of managers and by the individual member's past record of membership in the cooperative. A major part of member participation in the cooperative is realized through managers' technical and managerial skills. Past record of membership is an expression of member experience with cooperatives. This means that the level of member participation depends on their past record of membership leading to better familiarity with cooperative rules and regulations. Also, technical managerial skills of managers depend on the level of member care for technical criteria in electing managers. Although the value of R^2 shows a major portion of the variance in the independent variable not to be accounted for by this variable, evaluation of the variables affecting the manager technical skills was excluded from this study due to space limitations; however, the above equation was only introduced to show that a relation existed between the two variables. Interpersonal skills of managers are also affected by the two variables of age and importance attached by members to interpersonal criteria while electing managers.

To understand the effects of each independent variable on the success of poultry growers cooperatives, the direct effect of each factor is separately presented in Table 8 whereby the most effective factors are revealed.

Tab. 8: Magnitude of direct & indirect effects of independent variables on the dependent variable

Variable	Direct Effects	Indirect Effects	Total
Observance of technical criteria in electing managers	.166	.124*.400+.124*.196*.145	0.219
Observance of interpersonal criteria in selecting managers	.093	.120*.172+.120*.132*.145	0.116
Managerial skills	.400	.196*.145	0.428
Managers' interpersonal skills	.166	.132*.145	0.185
Exploiting cooperatives for personal interests	.133	-----	0.133
Training	.429		0.429
Number of training courses	.073	-----	0.073
Understanding of cooperativ preinciples	.149	-----	0.149
Member' participation in cooperative affairs	.145	-----	0.145
Age (Experience)	-----	.119*.149+.113*.166+.113*.132*.145	0.039
Duration of membership	-----	.435*.149	0.065
Education	-----	.228*.149	0.034

The coefficients of effectiveness presented in Table 8 show that training offered, technical skills of elected managers, observance of technical criteria in electing managers, and Interpersonal skills of elected managers with values of .429, .428, .219, and .185, respectively, are considered to be the most effective factors in the success of cooperatives. Also, exploiting cooperatives for personal interests by the managers was identified as one of the most crucial factors contributing to cooperative failures. In the light of the above considerations, the most important results obtained from this study can be summarized as follows:

1. The poultry growers cooperatives did not perform well in achieving their objectives. Our results are in good agreement with those from studies by Karami (2006), Amini & Ramezani (2006 a & b), Safavi Shali (2001), Aghajani (2001) and Sarsakhti (1995) carried out on different cooperatives in Iran.
2. Members and managers of firms are very little informed about the cooperative objectives and principles. This factor, with a coefficient of 4.028 has a positive effect on the success of cooperatives. These results are confirmed by investigations by Safari Shali (2001) and Aghajani (2001).
3. Member participation in cooperative affairs was considered by respondents to be moderate. This factor, with a coefficient of 1.249, has a direct effect on the success of cooperatives. Results from the route analysis show that member participation has a close correlation with interpersonal and managerial skills of managers.
4. Interpersonal skills of elected managers were considered to be higher than their technical skills by

the respondents in this survey. Results from the route analysis show that interpersonal and technical skills of managers directly affect the dependent variable with a coefficients of .428 and .185, respectively. These variables produce a positive effect on the success of agricultural cooperatives indirectly through member participation. Also, electing managers with due regard to interpersonal and technical criteria, with coefficients of .219 and .116, respectively, positively affect the success of cooperatives through the interpersonal and technical skills of managers.

5. Exploiting cooperatives toward personal interests by the managers, which is the most important limiting factor, with a coefficient of 1.883, had a negative effect on the success of cooperatives.
6. 54% of members and 74% of managers had received no training. Results from route analysis showed that training quality with a coefficient of 4.82 has a positive effect on the success of cooperatives. The results obtained here agree well with those obtained by Amini & Ramezani (2006 a,b), Karami (2006), Amini & Safari Shali (2002), Safari Shali (2001), Aghajani (2001) and Sarsakhti (1995).
7. Members' level of education was found to be below high school diploma, which was assessed as inappropriate for this type of business. Education positively affects the success of cooperatives with a coefficient of .034 through the intermediate factor of understanding of principles.

CONCLUSION

The following recommendations are in place in view of the results obtained from this study if improvements are sought upon poultry growers cooperatives:

- Given the poor quality of services offered by the staff involved in poultry growers cooperatives, and considering the technical nature of the business, it is essential to define long-term strategies with the objective of improving upon staff quality and skills. For this purpose, continuous education programs based on cooperative requirements will be helpful.
- Member participation in the process of decision-making may involve countless benefits for the cooperatives. In order to enhance member participation in cooperative affairs, suitable approaches need to be explored.
- The success of cooperatives depends on skills of managers. Since the managers lack adequate technical skills and some even have poor interpersonal skills, training programs may be designed and used to ensure the success of cooperatives.
- Based on the results of this study, member participation depends on managerial skills of cooperative managers. It is, therefore, necessary to formulate and employ modern managerial procedures so that managers could encourage member participation in cooperative affairs in their attempts to achieve the objectives of their respective cooperatives.

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Corresponding author:

Amini A.M.
University of Technology
Agricultural College
Dept. of Rural Development Studies
Isfahan, Iran
aamini@cc.iut.ac.ir

UTILIZATION OF alternative sources of energy IN CHILE

QUIROGA F., PRÁŠILOVÁ M., KREPL V.

Abstract

Current state of rural electrification in the field of renewable „non-conventional"sources in Chile presents high progress. Geological, climate and geographic conditions in Chile makes possibilities to generate energy from the renewable sources. At present the development status of projects in Chile is focused to the rural electrification.

Key words: renewable sources of energy, wind power, solar energy, water power, rural electrification, Chile

INTRODUCTION

The access to the electricity improves substantially the quality of life of the human beings. Nevertheless, in any cases, it is not profitable for the producer or distributor company, to supply with electrical energy to agricultural outlying communities. It is for this that these communities must auto generating his electricity. This Chilean isolated rural community, sometimes, generate electricity using renewable non-conventional sources.

In Chile there are four generation network (from the north to the south): SING or Sistema Interconectado Nortre Grande (Big North Interconnected System), SIC or Sistema Interconectado Central (Central Interconnected System), AYSEN and in the far south MAGALLANES.

Chile presents a continental length of 4.337 km and an average wide of 400 km, situated between the parallel 17°30´ and 56°32´ south latitude. Due to his big length, the country includes several climatic kinds.

Chilean potential in renewable sources energy

Due to geographical position, northern zone in Chile present a perfect potential to solar energy use, with monthly averaged daylight from 10 hours in winter time to 13 hours in summer time and at the same position (23 south latitude and 69° longitude) annual average insolarization incident on a horizontal surface is 5,91 $kWh/m^2/day$ (at Prague is only 2,95 $kWh/m^2/day$).

In the opposite, the south zone is cloudy and far from the Equator, then solar energy is not viable. But there is an enormous potential in wind and hydro sources.

Climates kinds cause many types of fluvial status. Another factor that affects the Chilean hydrology is the geography since in the eastern zone is Andes and in the west is the Pacific Ocean. The Endorreican region (rivers with ephemeral courses that do not end in the sea) spreads from the limit with Peru up to the river Loa and includes Puna de Atacama. The "arreican" region (no exist superficial flow) extends from the river Loa to the river Copiapó (Atacama Desert) where only there exist gouache or launderings of underground waters. The "exorreican" region (rivers that end in the sea during all the year) include the whole rest of the territory from river Copiapó up to the Patagonia.

Chile also present a big geothermal potential because most of the geothermal activity in the world occurs in an area known as the "Ring of Fire." which rims the Pacific Ocean and is bounded by Japan, the Philippines, the Aleutian Islands, North America, Central America, and South America (included Chile with its Nasca fault). But this source is not rentable in small scale exploitation.

Actually only mining industry and big scale electric generator are using this source. This kind of plants require a high initial investment, making impossible its application in agricultural outlying communities.

In the central and south zone, Chile present many hectares of forest, cellulose plants, agricultural production and other activities what can produce energy from biomass.

Chile possesses important water resources and the hydroelectric use constitutes are around the 55% of the capacity installed in plants of generation of electrical energy in the Electrical Interconnected Systems. Actually, the hydraulic potentials take advantage only in 19 % in relation to the entire potential. In case of the small scale systems to, the well used potential is in percentage terms very much minor, nevertheless, due to the peculiarity of the Chilean geography, with big falls of water in short distances (the mountain are next to the coast), an enormous potential exists for small hydroelectric uses.

Considering the big extension and geography of Chile, country crossed by some principal and other many smaller rivers, as well as for creeks, the use of his waters in small hydraulic outlying head offices should be a reality, during they could be competitive. Many mountainous places in almost the whole extension of the central and south Chilean zones, especially areas as continental Chile and outlying zones of the XIth and XIIth region, are adapted specially for the installation of multiple small water power station.

Current state in electrical generation with renewable sources in Chile.

With regard to the small hydroelectric uses, in Chile there are almost 350 micro and mini hydroelectric power station destined principally to the electrification of housings, specially in localities isolated in the south zone, where the hydrological conditions are the suitable ones. Approximately 88% is constructed by national manufacturers, being evident an increase in the manufacture in the decade of the 70. The manufacturers companies appear mostly in the 90s constructing generally medium and small turbines Pelton and Banki.

At present in Chile, design, construction and programming of maintenance and operation of small water power station, is principally manage by the National Program for Rural Electrification (PER) coordinated by the National Energy Commission (CNE). The PER was created by the CNE at the end of 1994, in order to give a solution to the lacks of electricity in the rural environment, diminishing the incentives that generate the migrations towards urban zones, encouraging the productive and guaranteed development a stable flow of public investments.

In parallel, the Global Environmental Facility (GEF) is co financing the project "Removal of Barriers to the Use of Renewable Energies Sources for Rural Electrification in Chile". In September, 2001 was signed the agreement CHI/00/G32 between the Program of the United Nations for the Development (UNDP), the CNE and the Chilean Department of Foreign Affairs. The purpose of the project is remove the barriers that prevent the use of technologies based on Renewable Energies on the rural electrification in Chile, across the development of a set of activities that will allow with it to reduce the gas emission of greenhouse effect produced by the energy supplying in the rural world.

The Table 1 show current state of projects in the GEF program. It is a quite wide portfolio that affects a whole of 9.873 housings of very outlying rural sectors and with lack of basic services. Photovoltaic system are the most important with 6.358 housing, then small hydro with 1.403 housing, hybrid (hydro-diesel) 1.047, hybrid (PV-diesel) 475 and finally wind project in the south zone with 68 housing. Non biomass or geothermal projects are included in this program.

Table 2 show the Chilean electrical generation installed capacity in MW in the year 2005 and make a parallel between conventional and renewable sources in the four Electrical Systems in Chile measured by the National Energy Commission. Geothermal and solar generation are not mentioned in this table.

CONCLUSION

Actually, the enormous potential of renewable sources is not correctly exploited in Chile. The most important causes of this problem are: Low budget form governmental organizations and NGOs to implement new projects, users are not aware of the ecological advantage using renewable sources to generate electricity and potential users are not informed about the different system to generate electricity by renewable sources.

Then, is recommended that the government modificate the rural electrification program, using in big scale solar energy in the northern zone and wind power in the south.

Hydropower is correctly exploited and the energy from biomass is starting to be implemented.

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Tab. 1: Projects related with the use of renewable energies sources for rural electrification in Chile

Region	District	Project name	Type	Housing	Project situation
I	Arica	Híbrido Valle Chaca	Hybrid (PV-Diesel)	25	Pre-feasibility
I	Camarones	FV Camarones	PV system	50	Pre-feasibility
I	Camarones	MCH Esquiña e Illapata	Small Hydro	42	Pre-feasibility
I	Camiña	Híbrido Nama	Hybrid (PV-Diesel)	28	Pre-feasibility
I	Iquique	Híbrido Caleta San Marcos	Hybrid (PV-Diesel)	70	Pre-feasibility
I	Huara	Híbrido Achacahua	Hybrid (PV-Diesel)	19	Execution phase
II	Calama	Híbrido Cupo	Hybrid (PV-Diesel)	11	Pre-feasibility
II	Ollagüe	Híbrido Ollagüe	Hybrid (PV-Diesel)	80	Pre-feasibility
II	Ollagüe	FV Ollagüe	PV system	18	Project
II	San Pedro	Híbrido Camar	Hybrid (PV-Diesel)	10	Project
II	Loa	FV el Loa	PV system	60	Project
II	Tocopilla	FV Tocopilla	PV system	11	Project
II	San Pedro	Micro centrales de Socaire, Talabre y Río Grande	Small Hydro	121	Done
III	Huasco	Híbrido Carrizal Bajo	Hybrid (PV-Diesel)	100	Pre-feasibility
III	Chañaral	Híbrido Pan de Azúcar	Hybrid (PV-Diesel)	20	Pre-feasibility
III	Regional	FV Regional	PV system	441	Project
IV	La Serena	Híbrido Almirante Latorre	Hybrid (PV-Diesel)	70	Pre-feasibility
IV	La Higuera	Híbrido Los Morros	Hybrid (PV-Diesel)	42	Pre-feasibility
IV	Regional	FV Escuelas y Postas (1)	PV system	55	Project
IV	Regional	FV viviendas y establecimientos rurales (2)	PV system	3064	Execution phase
IV	Regional	Mejoramiento sist. FV instalados (3)	PV system	1500	Pre-feasibility
V	Petorca	no information	no infromation	38	Project
VII	Colbún	FV El Melado	PV system	21	Done
VII	Regional	FV Regional	PV system	365	Project
VII	Empedrado	FV Proboste	PV system	21	Project
VIII	Arauco	FV Arauco	PV system	424	Project
VIII	Bio Bio	FV Bio Bio	PV system	164	Project
VIII	Ñuble	FV Ñuble	PV system	164	Project
VIII	Coronel	Isla Santa María	no infromation	490	Pre-feasibility
X	Cochamó	Valle El Frío	Small Hydro	5	Pre-feasibility
X	Cochamó	Paso El León	Small Hydro	16	Pre-feasibility
X	Cochamó	El Manso	Small Hydro	12	Pre-feasibility
X	Cochamó	Sotomo Alto	Small Hydro	10	Pre-feasibility
X	Cochamó	San Luis	Small Hydro	50	Pre-feasibility
X	Cochamó	Segundo Corral	Small Hydro	15	Pre-feasibility

Region	District	Project name	Type	Housing	Project situation
X	Cochamó	Llanada Grande	Small Hydro	54	Project
X	Purranque	Caleta San Pedro	Small Hydro	7	Pre-feasibility
X	Purranque	Manquemapu	Small Hydro	15	Pre-feasibility
X	Chaiten	Caleta Loyola	Small Hydro	16	Pre-feasibility
X	Chaiten	Chumelden	Small Hydro	10	Pre-feasibility
X	Futaleufu	Valle El Espolón	Small Hydro	6	Pre-feasibility
X	Futaleufu	Las Escalas	Small Hydro	12	Pre-feasibility
X	Futaleufu	La Dificultad	Small Hydro	5	Pre-feasibility
X	Futaleufu	Río Chico	Small Hydro	4	Pre-feasibility
X	San Juan de la Costa	Barra del Río Bueno	Small Hydro	13	Pre-feasibility
X	San Juan de la Costa	Caleta Milagro	Small Hydro	3	Pre-feasibility
X	Corral	Cadillal Alto(Dimter)	Small Hydro	9	Pre-feasibility
X	Corral	Cadillal Alto Don Omar	Small Hydro	8	Pre-feasibility
X	Chaiten	Auteni	Small Hydro	25	Pre-feasibility
X	Calbuco	Tabón	Small Hydro	142	Pre-feasibility
X	Queilen	Acuy	Small Hydro	22	Pre-feasibility
X	Calbuco	Chaullin	Small Hydro	26	Pre-feasibility
X	Chaiten	Chuit	Small Hydro	35	Pre-feasibility
X	Chaiten	Chulin	Small Hydro	50	Pre-feasibility
X	Chaiten	Imerquiña	Small Hydro	6	Pre-feasibility
X	Hualaihue	LLanchid	Small Hydro	19	Pre-feasibility
X	Chaiten	Nayahue	Small Hydro	31	Pre-feasibility
X	Calbuco	Quenu	Small Hydro	55	Pre-feasibility
X	Chaiten	Talcan	Small Hydro	48	Pre-feasibility
X	Quemchi	Teuquelin	Small Hydro	11	Pre-feasibility
XI	Natales	MCH Gaviota	Small Hydro	500	Project
XI	Guaitecas	Proyecto Híbrido Melinka y Repollal	Hybrid (hydro-Diesel)	450	Project
XI	Aisen	Proyecto Híbrido Islas Huichas	Hybrid (hydro-Diesel)	107	Pre-feasibility
XI	Cisnes	Proyecto Híbrido Islas Grupo Gala	Hybrid (hydro-Diesel)	490	Pre-feasibility
XII	Pueto Natales	Villa Renovales	Wind	12	Pre-feasibility
XII	Laguna Blanca	Villa Tehuelche	Wind	50	Pre-feasibility
	(1)	***Schools and Rural Health Clinic***	TOTAL	9873	
	(2)	***Rural housing***			
	(3)	***Improvement PV system***			

Source: Data base of project Removal of Barriers to the Use of Renewable Energies Sources for Rural Electrification in Chile

Tab. 2: Electrical Generation Installed Capacity [MW] Year 2005

Electrical Generation Installed Capacity [MW] Year 2005						
	Source	SING	SIC	Aysen	MAG	Total
Conventional	Hydro > 20MW	0	4612,9	0	0	4612,9
	Diesel	3583	3422,1	13,88	64,7	7083,7
	Total	***3583***	***8035***	***13,88***	***64,7***	***11696,6***
Renewable	Hydro < 20MW	12,8	82,4	17,6	0	112,8
	Biomass	0	170,9	0	0	170,9
	Wind Power	0	0	2	0	2,0
	Total	***12,8***	***253,3***	***19,6***	***0***	***285,7***
TOTAL		**3595,8**	**8288,3**	**33,48**	**64,7**	**11982,28**
Renewable Sources %		**0,4**	**3,1**	**58,5**	**0,0**	**2,4**

Source: CNE data base

Corresponding authors

Assoc. Prof. Krepl V., Ph.D.
Czech University of Life Sciences Prague
Institute of Tropics and Subtropics
Czech Republic
krepl@its.czu.cz

THE INFLUENCE OF GROWTH REGULATORS ON ROOT INDUCTION *IN VITRO* OF THE *MUSA* GENUS

VIEHMANNOVÁ I., FERNÁNDEZ C.E, HNILIČKA F., ROBLES C.D.

Abstract

The influence of growth regulators on the root induction of the Musa genus plants cultivated within in vitro conditions has been compared. The plant material used was the 'Cavendish' cultivar. Different concentratios of growth regulators (naphthaleneacetic acid, indole-3-acetic acid, 6-benzylaminopurine, 2.,4-dichlorophenoxyacetic acid) has been used and as control ones MS and half concentrated MS media without additon of growth regulators. The induced roots were evaluated in conditions in vitro and ex vitro. The amount and length of the roots were evaluated, as well as the capacity of absorption of the roots by conductivity was determined. The experiments have proven that the most roots are created by using naphthaleneacetic acid (5.4 μM), but the longest roots provide the control variant (MS medium). After 7 weeks of the transfer to ex vitro conditions the plants that were growing on medium with addition indole-3-acetic acid have the best vitality and root absorption.

Key words: banana, Cavendish, conductivity, micropropagation, root evaluation.

INTRODUCTION

The majority of bananas planted for the fruit production is seedless, therefore they are reproducing mostly vegetatively using sprouts or chopped rootstocks with eyelets. However, these types do not allow to prepare sufficient amount of suitable vegetal material in case, when the new breed shall replace the old one or in case when it is necessary to propagate enough plants of the new resistent cultivars for the field testing purposes and its spreading. These causes have been an impulse for the banana micropropagation technologies development, that is effective way of propagating of large amount of genetically identical entities in aseptical *in vitro* conditions. The average rate of shoot formation pro-duced by this technique are 4–5 shoot per monthly subculture (Priyono, 2001). Naturally, banana has high potency to produce large number of small corms. Thus the *in vitro* technique for inducing cormolet initiation followed by its development to form micro sucker is prospective method to improve the commercialised of banana *in vitro* technique (Priyono, 2001). Even though many authors have already been dedicated to the problematics of the *in vitro* banana growing techno-logies (Roels et al., 2005; Albany et al., 2005; Assani et al., 2003; Bajaj, 1995); Cronauer and Krikorian, 1984; Hwang et al., 1984) and to the optimisation of separate phases of micropropagation to speed up its proceeding, there is still space remaining for certain improvements and comparations of different variants and solutions are being offered by individual authors. In the presented work the suitability of media containing various concentrations of growth regulators (auxins and cytokinins) is being tested for its influence on root induction of the banana cultivated *in vitro* and, root quality that enables successful transfer to *ex vitro* conditions.

MATERIAL AND METHODS

Plant material

Triploid cultivar of the Cavendish group was used. Triploid of the type acuminata with AAA constitution, significantly spread species bringing huge yields of quality fruit bananas, is distinguished with increased resistance against colder climatic circumstances, is panama disease resistant, but sigatoca disease susceptible (Pospisil and Hrachova, 1990). The group AAA in comparation to planteins (group AAB) many well-developed suckers, in condition *in vitro*, the micropropagation rate is 3 to 5 fold every multiplication cycle (Roels et al., 2005).

Establishment phase

The explants were before the transfer to *in vitro* conditions surface-sterilized for 1 min in 70% ethanol, 23 min in 1% solution of NaClO with a few drops of Tween 20. They were rinsed then tree times with sterile destiled water and transferred to proliferation medium (Cronauer and Krikorian, 1984) into 50 ml flasks filled with 25 ml of medium.

Proliferation phase

After 28 days the developing shoots were subcultured at least four times on the same medium before use as a starting material for the experiments.

METHODOLOGY

Media and culture condition for root induction

The experiment testing the suitability of the media for root induction of the banana was initiated with following variants: 1) MS (Murashige and Skoog, 1962) 2) ½ MS; 3) MS + 5.4 µM NAA (naphthaleneacetic acid) + 13.3 µM BA (6-benzylaminopurine); 4) MS + 2.3 µM 2,4-D (2,4-dichlorophenoxyacetic acid); 5) MS + 4.6 µM 2,4-D; 6) MS + 2.7 µM NAA; 7) MS + 5.4 µM NAA; 8) MS + 2.9 µM IAA (indole-3-acetic acid); 9) MS + 5.7 µM IAA; 10) MS + 8.7 µM IAA; 11) MS + 11.6 µM IAA; 12) MS + 14.5 µM IAA; 13) MS + 17.4 µM IAA.

Vegetative explantates were cultivated at 23 ± 2°C under cool white fluorescent tubes (NARVA LT 36 W/010) providing a photosynthetic active radiation of 30 µmol. m^{-2}. s^{-1} with a photoperiod of 16 hours.

Plant transfer to ex vitro condition

After 30 days of cultivation in conditions *in vitro* the plants were transferred to semi-sterile substrate (mixture of soil and pearlite in ratio 3:1). The temperature during the cultivation in *ex vitro* conditions (greenhouse conditions) was reaching on average 21.5°C during the day and 18.0°C during the night. At the beginnig the plantlets were covered with PP film (polypropylene film) to maintain high RH (relative humidity).

Root evaluation, statistics

The formation of roots by individual variants has been observed for 28 days in regular intervals of 7 days. The amount and length of the roots have been registered. To complete the experiment, the formation of shoots has also been observed. The growth of the roots (that is the number and length of roots) by different plants has been processed by statistic program STATISTICA 6.0 CZ (statistica base cz) with level of significance of $\alpha = 0.05$. The average values of partial parameters in the single variants were entered into the Table 1. Any conta-minated cultures were deleted from the experiment. The success of transfer to ex *vitro* conditions was evaluated in percentage.

Measurement of absorption strength of the root by conductivity

The root adsorption strength was tested using the conductivity. After 4 weeks of cultivation of the banana in the substrate the plants were taken out again, the roots rinsed with water and compared with the status in the beginning of *ex vitro* transfer. The experiments were held during 10 days. The principle of the testing, which has to compare the different adsorbtion capacity of the root, is in the decrease of ionts dissolved in the ½ MS solution (withouth sugar and agar) during cultivation of single banana plants in this solution. To compare the adsorbtion power of the roots, created on the control medium MS, medium MS with addition of IAA at the concentration of 5.7 µM and medium MS with 5.4 µM of NAA, a trial based on conductivity of solution has been proposed. The three tested variants were chosen as representative according to the growth regulator used and also its amount (i.e.1 mg. l^{-1}). Specific conductivity was measured on conductometer ino Lab, Cond Level 1 under constant temperature of 21 °C. Condutiometer measures the resistance of given solution and gives the final value in µS.cm^{-1} to v mS.m^{-1}.

RESULTS

From the results obtained in the statistical analysis emerges that the largest number of roots has been found with the variant 5.4 µM NAA (14.79 roots per plant). The variants 2.3 µM and 4.6 µM 2.4 – D.l^{-1} did not create any roots at all (Table 1). Evidential differences were not found among variants with addition of IAA at concentrations of 5.7 µM, 11.6 µM and 14.5 µM and also among variants 2.9 µM IAA.l^{-1} and ½ MS. The biggest average length of the roots has been measured with variant MS (36.54 mm), Table 1. The differences in length of the roots have not been evidential among variants 8.7 µM IAA, 14.5 µM IAA and 5.4 µM NAA.

The Figure 1 shows visibly the indirect proportion between average length and number of the roots createed within the framework of variants. This trend is mostly visible among variants ½ MS, MS and medium containing NAA. The roots created at the control media MS and ½ MS were in comparison with other variants longer (avg. length 35.81 mm), but their number was lower (avg. 8.77 roots; Figure 2a). Roots created on the media with addition of IAA were similar to those on MS medium (Figure 2b).On the other hand the roots created on the media supplemented with NAA were rather short (avg. length 23.31 mm), but their number was in comparison with other variants high (avg. amount of 14.00 roots; Figure 2c).

The comparison of variants NAA (5.4 µM) + BA (13.3 µM) with variant NAA (5.4 µM) is also worth mentioning. Whilst the average length of the root with variant 5.4 µM NAA was 21.99 mm and the amount was 14.79 roots, the variant NAA + BA created on average only 2.20 roots with average length of 8.49 mm. Using the same concentration of NAA the variant NAA + BA created only 14.87% of the roots of variant NAA and the roots reached 38.61% of the length of 5.4 µM NAA variant. The addition of BA at the concentration of 13.3 µM in the medium with 5.4 µM NAA has suppressed the creation of adventive roots of 85.13% and average length of the root of 61.39%. Nevertheless the creation of sprouts has been increased by 70.02%.

Media with NAA + BA addition, which has created a great number of shoots and small number of roots; were more difficult to induce root and 37% did not survive the transfer into *ex vitro* conditions. While this variant was highly successful in conditions *in vitro*, the most of the plants perished in conditions *ex vitro* out of all the compared variants that created roots.

Variants with the addition of IAA had the highest survival percentage (90%), followed by variants with NAA (78%). All the transferred plants of variant 2.4-D perished.

The results of evaluation of roots by the means of conductivity

Variants labelled "I" were tested on conductivity immediately after the end of 4-week cultivation *in vitro* conditions labelled "II" were kept another 4 weeks in substrate (*ex vitro*). When the plants were taken out of substrate, their rootage, created already *in vitro* conditions, seemed to be still operational.

Plants tested immediately after the transfer from *in vitro* conditions had generally lower sucking power (expressed by the average fusion volume shortage – 30 ml) in comparison with the plants cultivated in *ex vitro* conditions (63 ml). The difference was more than double (Table 2).

Roots created on the medium with addition of IAA kept approximately the same sucking power (measured by the fusion volume decrease), done either out of *in vitro* conditions (decrease by 29 ml) or after 4 week culti-vation in substrate (decrease by 35 ml). While in the first case roots showed the average performance in comparison with the other variants, in the second case suction capacity was below standard. After 7 weeks of cultivation in the soil new functional roots started to appear and they replaced the older ones created in conditions *in vitro*, which allowed a fluid nutrition and the plants of this variant at the end of the experiment had the best growth.

Roots created on the medium with addition of NAA had really small absorbing power after the transition into *in vitro* conditions (decrease of fusion by 23 ml). These roots though adapted on soil conditions really fast and their suction capacity became the highest out of all the tested variants (decrease by 83 ml). After next 3 weeks of cultivation all the roots die out and the plants desisted in growth.

MS medium gave rise to roots with good suction capacity, which increased proportionally with the age of the plant and the transition into the *ex vitro* conditions (MS I recorded the decrease by 39 ml, MS II 71 ml). After 7 weeks in conditions *ex vitro* new roots began to replace the old ones like in variant IAA.

Plants tested immediately after the transition from *in vitro* conditions had on average lower sucking power of the roots - expressed by the conductivity of the solution – out of original 2.77 $mS.cm^{-1}$ to 2.39 $mS.cm^{-1}$ in comparison with the plants cultivated consequently in *ex vitro* conditions (out of original 2.77 $mS.cm^{-1}$ to 1.84 $mS.cm^{-1}$), Table 2.

DISCUSSION

The experiments showed that medium with the supplement of synthetic auxin 2.4-D is absolutely unsuitable for the optimization of the rootage. Even though Prochazka and Sebanek (1997) mention that its low concentrations stimulate the production of roots and very often induce the production of the callus, neither of these presumptions was not confirmed. Not even the medium with the supplement of auxin and cytokinin, as recommended by Prochazka and Sebanek (1997) for the production of adventitious root does not appear suitable for the rootage of the banana. The above mentioned medium would be more suitable for the proliferation phase of micropropagation, where the main goal is to get as high number of reproduction propagules. Control media MS (without growing regulators) and ½ MS, as recommended by Pocasangre (1993) reveals to be efficient. Another tested medium with the supplement of NAA was published by Cronaur and Krikorian (1984), Ganapathi et al. (1995), pointed out on the ability of NAA to induce the root formation. Banana plants created on the medium with NAA had different rootage in comparison with the others regulators – there were more roots and were shorter. Roots were growing in several waves. Using media with the supplement of IAA and NAA and MS medium without addition of growth regulators roots really started creating after 5–7 days. On medium with the supplement of NAA and BA the roots started appearing the 12^{th} day.

In accessible publications there is no data that informs on the functionality of the roots induced *in vitro*. Our results demonstrated that the induced roots maintain their functionality after the transfer to *ex vitro* conditions. After 4 week cultivation of the bananas in conditions *ex vitro* the greatest absorption has the roots induced on the medium with the addition of NAA. After next 3 weeks these roots die out. The best variant is therefore medium with the addition of IAA where the older roots are gradually replaced with the new ones.

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Tab. 1: Phenotype of plants after 30 days of cultivation

Variation	Roots average per plant	Roots length average (mm)	Shoots quantity average per plant	Roots quantity average per shoot	Leaves average per plant
1/2 MS	8.43±1.36	35.07±8.81	1.58±0.64	1.11±0.39	3.88±0.82
MS	9.10±1.21	36.54±9.11	2.07±0.59	1.26±0.45	4.47±0.93
NAA (5.4 μM) + BA (13.3 μM)	2.20±0.87	8.49±2.65	4.57±1.01	0.27±0.52	3.33±0.51
2.4-D (2.3 μM)	0.00	0.00	0.00	0.00	1.73±0.36
2.4-D (4.6 μM)	0.00	0.00	0.00	0.00	2.00±0.23
NAA (2.7 μM)	13.20±1.32	24.62±5.04	3.73±0.88	1.10±0.54	3.72±0.77
NAA (5.4 μM)	14.79±2.36	21.99±6.29	1.37±0.47	2.78±0.82	4.00±0.64
IAA (2.9 μM)	8.97±0.98	28.53±7.45	1.67±0.87	1.52±0.78	4.60±0.87
IAA (5.7 μM)	9.73±1.35	24.16±7.66	1.50±0.61	0.88±0.79	4.13±0.76
IAA (8.7 μM)	11.05±2.02	22.71±6.84	1.85±0.79	1.59±0.85	3.25±0.84
IAA (11.6 μM)	10.80±1.83	24.55±5.21	1.55±0.58	2.45±0.96	3.10±0.36
IAA (14.5 μM)	10.85±1.33	22.33±6.33	1.15±0.21	2.74±1.15	3.32±0.57
IAA (17.4 μM)	9.80±1.12	24.34±7.96	1.00±0.12	3.20±0.74	2.95±0.33

Tab. 2: Volume rate and conductivity value in selected variables

Evaluation	date/days	IAA I	IAA II	NAA I	NAAII	MS I	MS II
Volume (ml)	1. day	145	145	145	145	145	145
	7. day	122±5.7	114±7.2	126±9.1	88±5.3	114±7.9	90±6.4
	10. day	116±6.9	110±9.3	122±11.6	62±8.5	106±10.5	74±8.7
Conductivity (mS. cm^{-1})	1. day	2.77	2.77	2.77	2.77	2.77	2.77
	7. day	2.78±0.01	2.81±0.01	3.01±0.02	2.96±0.01	2.91±0.01	2.93±0.02
	10. day	2.82±0.02	2.90±0.01	3.18±0.02	3.47±0.02	3.08±0,02	3.27±0.02
	10. day*	2.29±0.02	2.20±0.02	2.64±0.03	1.57±0.02	2.25±0.02	1.75±0.03

Note: 10. day* = conductivity values of the measured solution the tenth day after adding the missing volume at the original of 145 ml
The solution temperature during the conductivity measurement was 21°C.
The solution evaporation (except for the leaves) during the experiment was stipulated in 10%.
Maximum loss of rots during the test 5%.

Fig. 1: Comparation of average root length and quantity of roots in different variants

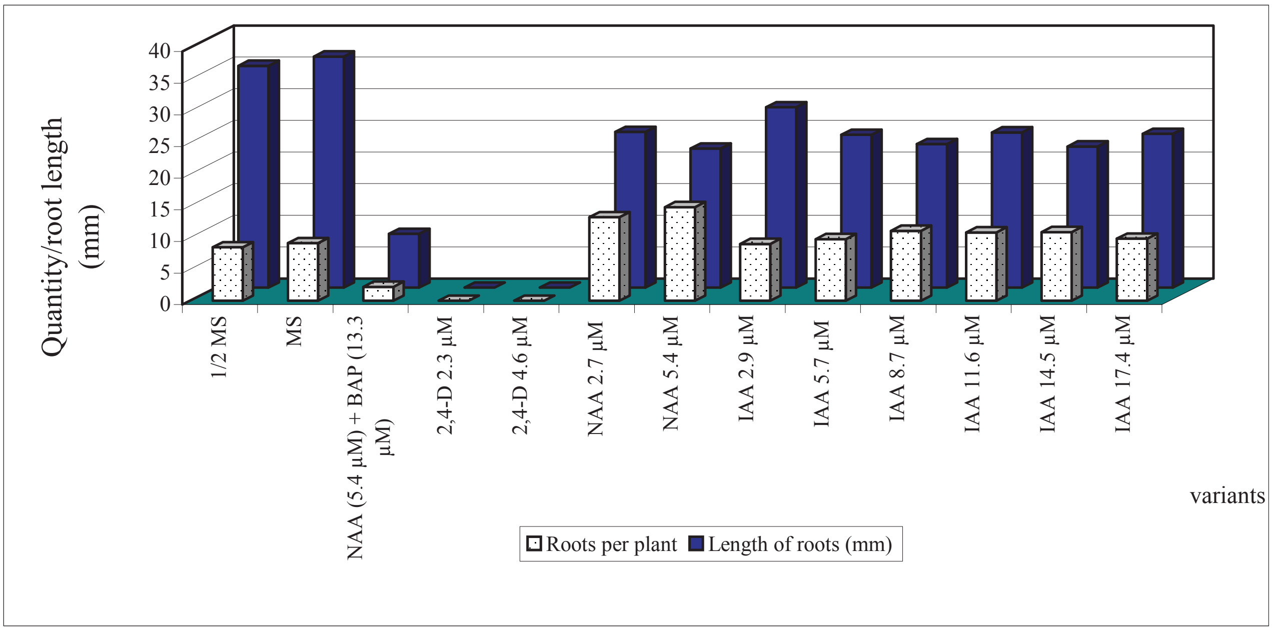
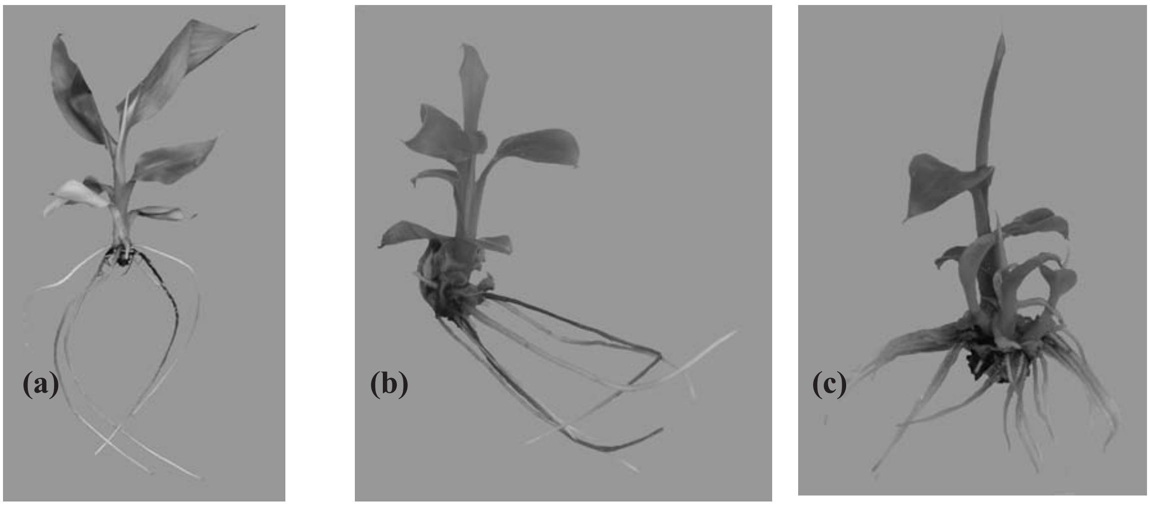


Fig. 2: Root formation on MS medium withouth growth regulators (control variant) – a) and with the addition of 8.7 µM IAA – b) and 5.4 µM NAA – c) after 4 weeks of cultivation in conditions *in vitro*. Significantly different roots are created on the medium with NAA, they grow up in several waves in radial direction and they are markedly shorter and thicker.



Corresponding author:

Corresponding author:

Ing. Iva Viehmannová
Czech University of Life Science Prague
Institute of Tropics and Subtropics
Czech Republic
Viehmann@its.czu.cz

MUSHROOM GROWING WITH INFORMATION SUPPORT AS OPPORTUNITY FOR THE DEVELOPING COUNTRIES

VOSTROVSKÝ V., JABLONSKÁ E.

Abstract

This article describes the possibility of the mushroom growing with information support in the developing countries. Mushrooms growing can be a big opportunity for the developing countries. Very suitable above all can be the oyster mushroom growing. The successful oyster mushroom growing in developing countries will need a reasonable information support. This support may be performed by combination of ELearning and expert systems among others. Such solutions can be used for example at consulting centres of developing countries for producing of the oyster mushrooms. These features are demonstrated at the example of the mushroom growing in China and Kenya.

Key words: knowledge, expert system, eLearning, expert eLearning, developing countries, Oyster mushroom growing, waste management

INTRODUCTION

Growing mushrooms can be a big opportunity for the developing countries. Very suitable above all can be the oyster mushroom growing. There are some special advantages of the mushroom growing in the developing countries:

- abundance of plant waste for the substrate (straw, corn cobs, bagasa, sawdust, crop stalks and other agricultural and forest waste can be used to grow mushrooms),
- mushroom growing can solve problem of the protein meals insufficiency and starvation,
- it can increase insufficiency of the job opportunities,
- expensive mechanisation could be compensated by cheap manpower.

The market for mushrooms continues to grow due to interest in their culinary, nutritional, and health benefits. They also show potential for use in waste management. Importance of the mushrooms is following:

- Mushrooms have good nutritional value.
- Mushrooms provide high levels of protein, minor elements, vitamins and amino acids (white button mushrooms, for example, contain more protein than kidney beans.
- Mushrooms are the unique health food. Most of them have natural anti-viral and immunity-boosting proper-ties that are used to fight viruses, lower cholesterol and regulate blood pressure.
- Mushrooms are ecologically important. Mycelium in substrate is active in remediation of contaminated soils.

These opportunities can be demonstrated on the oyster mushroom growing in China. The mushroom cultivation in China has a long-lasting tradition. Mushrooms have been grown there for hundreds of years. It utilizes reserves of cheap labour, sufficiency of the matter for substrates and popularity in the Chinese board. The following table and graphs illustrate the mushroom growing level in China:

Mushroom growing can be a valuable method used to fight poverty and starvation. It can make agriculture more efficient and make money for farmers. For example there was realized a project in 1989 to help people in poverty stricken areas of China learn how to grow mushrooms for self-supply. In Shouling county in Fujian, there were many people living below the poverty line. 94% of the families were involved into the project. Since then, mushroom cultivation in that county has become more and more economically significant. The inhabitants are now emerging from extreme poverty (Oei, 1996).

Another proof of the economic potential of mushroom growing on developing countries is project in oyster mushroom production targeted for small-scale farmers in Kisumu (Kenya 2004). In March 2005, a demon-stration on oyster mushroom production and processing was conducted in Busia and attended by 250 parti-cipants. Mary Kariaga, who participated in this project, produced 120 kg of oyster mushroom in a small room making a profit of KSh 37,630 (i. e. 5000 $) in only three months (Giarratano, Riley, 1998).

MATERIAL AND METHODS

Mushroom production is on the other hand labour and expertly intensive. It requires a considerable amount of knowledge, research, planning and capital investment to set up a production system. The main disadvantage of the oyster mushroom growing in the developing countries is the lack of the necessary information resources.

The oyster mushroom growing can be complicated by the following factors:

Bacteria
The most common bacterial problem encountered by growers is *Pseudomonas tolaasii*. Infected mushrooms have a reduced shelf life. Lowering r.h. to 80 to 85 percent, and sprinkling the surface of the bags between flushes with 0.2 percent bleach solution may help maintain control.

Fungii
Most fungi encountered in oyster mushroom production grow and develop on the substrate and are very rarely parasitic.

Deformed fruit bodies
Deformed mushrooms may result from several causes, many of them still unknown. However, most deformed mushrooms may be traced to insufficient light and ventilation, chemical vapours and overheated substrate during spawn run.

Airborne spores
A single mushroom may produce up to 4 million spores per hour. Inhaled spores can cause an allergic reaction in some growers (Oei, 1996). New developed sporeless strains can solve that problem.
The growers need the appropriate information and knowledge to solve these problems. The successful oyster mushroom growing in developing countries will need a reasonable information support. This support may be performed by combination of ELearning and expert systems among others.

E-learning
E-learning is an effective use of information technologies (IT) in personal training process. It is available over the Internet, intranets, extranets (online) or CD and DVD (offline). It can support traditional learning and can be sometimes cheaper and faster (Kontis, 2007). This part of the proposed information support for oyster mushroom growing can make accessible the necessary information to users.
ELearning has some advantages and disadvantages over traditional teaching. There are some advantages:

- E-learning course is not only text and pictures transformed to electronic form. Through a number of multimedia objects (video, sound, simulation) can be learning more understanding.
- In less developed countries with less literacy is possible to use more speech, pictures and video.
- It is not necessary to start this course for a number of students – students can work individually.
- Students can study when they need it and when they are able to concentrate.
- Student has own pace of study.
- Student can review course or its part.
- Teachers do not waste time in repeating the same lectures in classes.
- Questions and tests are important part of eLearning course – through a number of questions, simulations and tests students are getting involved in the training which significantly increases their capability to remember things (Kontis, 2007).
- Courses can be updated, extended and modified very easily.

E-learning requires other money investing to create courses, implement management system etc. There are special Learning Management Systems (LMS) for supporting e-learning (WebCT, LearningSpace, Moodle etc.), but it is not necessary to use LMS. PowerPoint is the very popular tool for building e-learning courses. It is used as a powerful and efficient e-learning development environment.
The eLearning main disadvantage is that the user has to have the access to computer. For example, the latest estimates indicate that Kenya has Internet penetration of 4.4%, more than 1000 cyber cafes, computer penetration of 2%, television penetration of 60% and mobile phone penetration of 16% (MIT Media Laboratory, 2007). However, this situation moves forward. This disadvantage can be solved by building-up of training centres in the developing countries.
The following initiative can solve this problem. Media Lab of the Massachusetts Institute of Technology, along with the World Bank, plans to provide a $100 laptop to many millions of users in developing countries. It is also a huge responsibility, to make sure that the initiative really does help users to learn, in ways that are matched to their needs, interests and cultures (MIT Media Laboratory, 2007). The computer technology will not be sufficient, if the appropriate information resources will not be accessible as well.
The increasing importance of the eLearning in developing countries can be documented by 2nd International Conference on ICT for Development, Education and Training, Nairobi, Kenya May 2007. Meeting the networking needs of the Pan-African eLearning and distance education sector, the annual eLearning Africa conference (eLA) is the key networking venue for practitioners and professionals from Africa and all over the world. There are main facts: eLA is the largest gathering of eLearning and distance education professionals in Africa, enabling participants to develop multinational and cross-industry contacts and partnerships, as well as to enhance their knowledge, expertise, and abilities (eLearning Africa, 2007).

Expert systems
The second component of the proposed solution creates an expert system. Expert systems are part of general category of computer applications known as artificial intelligence. An expert system is a class of computer programs developed by researches in artificial intelligence during the 1970s and applied commercially throughout the 1980s. In essence, they are programs made up of a set of rules that analyze information (usually supplied by the user of the system) about a specific class of problems, as well as provide analysis of the problem(s), and, depending

upon their design, recommend a course of user action in order to implement corrections (Quimio, Chang, 1990). The expert systems have enhanced productivity in business, ecology, medical diagnosis, social sphere and the military. These systems can be applied for the oyster mushroom growing as well.

The typical expert system consists of

- knowledge base,
- inference engine and
- explanation facilities.

The knowledge base is the most important part of the whole solution, which implicates his total quality. This base contains the knowledge with which the inference engine draws conclusions (Giarratano, Riley, 1998). The basic scheme of a proposed solution is shown in Fig. 4**.**

The expert systems are usually designed to have the following general characteristics:

- **High performance.** The system must by capable of responding at a level of competency equal to or better than of an expert in the field.
- **Adequate response time.** The system must also perform in a reasonable amount of time, comparable to or better than the time required by an expert to reach a decision.
- **Good reliability.** The expert system must be reliable and not prone to crasher or it will not be used.
- **Understandable.** The system should be able to explain the steps of its reasoning while executing so that it is understandable (Holsapple, Whinston, 1996).

Expert system, as a component of the proposed information support, enables expert consultation of the oyster mushroom growing problems to its users. To illustrate such expert consultation we will suppose the following knowledge:

If the fruit bodies of the oyster mushrooms are miss formed, the fruit bodies have the long stipes and dwarfed huts and they look like on the picture**, then** cause is insufficient illumination of culture during fruit bodies´development.

The following rule will correspond with the above mentioned knowledge:

IF the fruit bodies of the oyster mushrooms are miss formed
AND the fruit bodies have the long stapes
AND the fruit bodies have dwarfed huts
AND they look like on the picture
THEN cause is insufficient illumination of culture during fruitbodies´development.

The expert consultation of the proposed solution is shown in Fig. 6**.** The user can be relocated into theoretical part of the eLearning application for more detailed information relating to the found solution.

CONCLUSION

The process of the oyster mushrooms growing in developing countries can be complicated by number of the problems. To solve these problems needs the appropriate information support. Proposed conception of expert ELearning information support should provide to its users:

- o long time education,
- o all time information resource,
- o expert consultation of the practical growing problems.

The proposed information support of the oyster muschroom growing has the following benefits:

- the availability of the saved information and knowledge,
- the lucidity of the saved information and knowledge,
- the efficient forwarding of the knowledge independent on the human subject,
- more visual presentation of the saved information by means of the multimedia components,
- more efficient way of the information and knowledge forwarding independent of the space, time and subject.

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Internet World Stats http:/www.internetworldstats.com

Wikipedia: http://en.wikipedia.org/wiki/expert_system

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Tab.1: Mushroom production in China (2002) (Jablonský, 2007)

Species	**Amount** (tons)
Pleurotus (oyster mushroom)	2 488 000
Lentinula	2 228 000
Aricularia	1 654 000
Agaricus	1 330 000
Volvariella	197 000
Flammulina	557 000
Tremella	183 000
Hypzisicus	242 000
Pholiota nameko	171 000
Coprinus	177 000
P. eryngii	114 000

Tab.2: World Internet usage and population (Internet World Stats, 2007)

World Regions	**Population (2007 Est.)**	**Internet Usage, Latest Data**	**% Population (Penetration)**	**Usage % of World**	**Usage Growth 2000–2007 (%)**
Africa	933,448,292	33,421,800	3.6	2.9	640.3
Asia	3,712,527,624	409,421,115	11.0	36.0	258.2
Europe	809,624,686	319,092,225	39.4	28.2	203.6
Middle East	193,452,727	19,424,700	10.0	1.7	491.4
North America	334,538,018	230,987,282	69.0	20.4	113.7

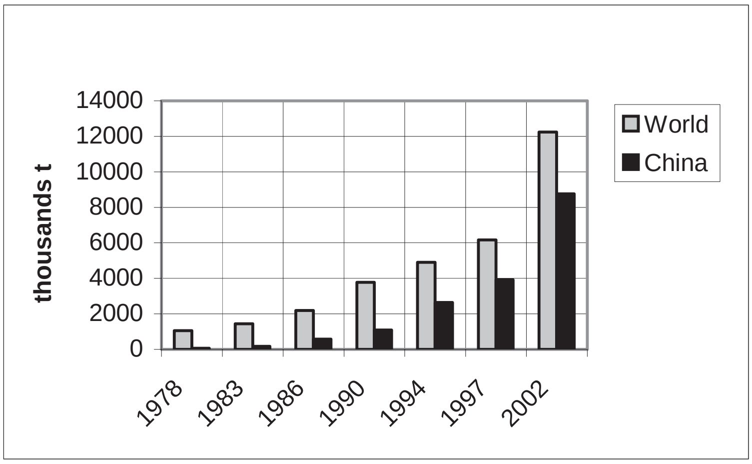

Fig. 1: Comparison of production in China and in the world (Jablonský, 2007)

Fig. 2: Picture of $100 laptop for developing countries (MIT Media Laboratory, 2007)

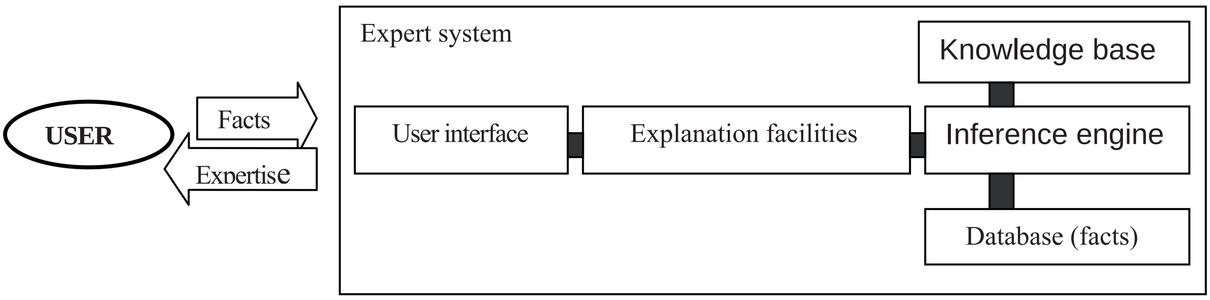

Fig. 3: Basic scheme of a typical expert system

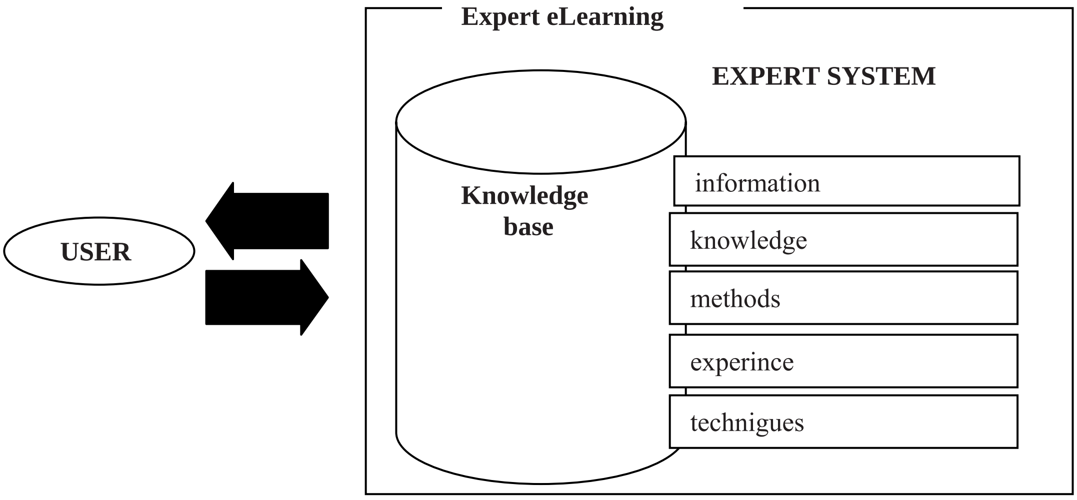

Fig. 4: Basic scheme of a proposed solution

Fig. 5: The realized prototype of the expert eLearning for the oyster mushroom growing

System: Are the fruit bodies of the oyster mushrooms miss formed? YES NO

Answer of user (mushroom grower): YES

System: Have the fruit bodies the long stipes? YES NO

Answer of user (mushroom grower): YES

System: Have the fruit bodies dwarfed huts? YES NO

Answer of user (mushroom grower): YES

System: Do they look like on the picture?

Answer of user (mushroom grower):

System: I conclude: cause is insufficient illumination of culture during development of fruit bodies.
Recommendation: Measure intensity of illumination and regulate its corresponding intensity.

Fig. 6: Example of the expert consultation of the oyster mushroom growing problems

Corresponding author:

Dr. Ing. Vostrovský V.
Czech University of Life Sciences Prague
Faculty of Economics and Management
Department of Information Engineering
165 21 Prague 6-Suchdol, Czech Republic
vostrovsky@ pef.czu.cz

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