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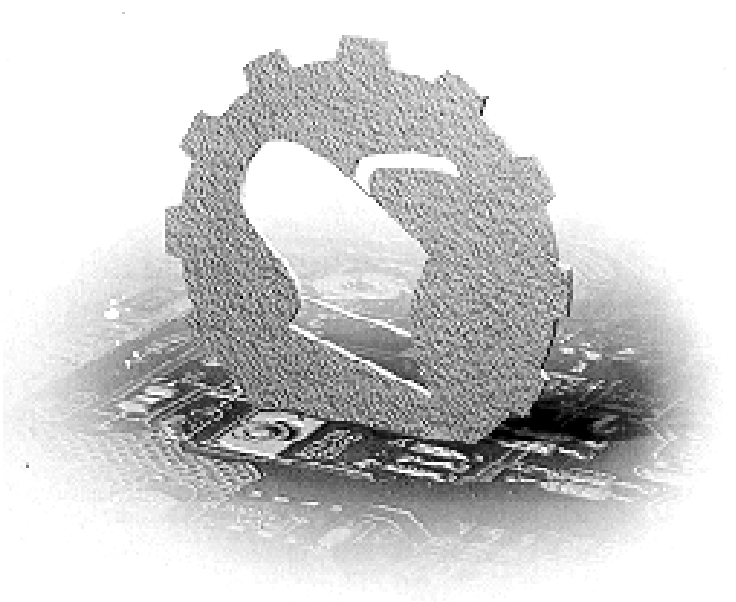

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DESIGN, DEVELOPMENT AND FIELD EVALUATION OF RAISED BED INCLINED PLATE PLANTER FOR DIRECT SOWING OF ONION (*Allium Cepa* L.) SEED ON BEDS

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Department of Farm Machinery & Power Engineering, Ludhiana, Punjab, India

Abstract: In India Onion (*Allium cepa* L) occupies an area of 1064 thousand ha, with production of 15118 thousand tons. The export of onion during 2011 -12 was 13,09,863.26 thousand tons with a value of *Rs* 1,722.85 crores. India is the 2nd largest producer of onion, in the world next only to China but the productivity of onion in India is very low i.e. 14.21 t.ha^{-1} as compared to China and other countries like , Egypt, Netherlands, & Iran etc. India is the world's second largest producer of vegetables after China. Timeliness of operations and efficient use of the inputs are the important keys in achieving higher levels of productivity and quality. In order to increase area under onion cultivation and make it competitive and profitable, it is important to introduce mechanized technologies for its cultivation. Manual sowing and transplanting of onion is very laborious and costly operation. Therefore to mechanize its sowing operation a tractor operated raised bed planter with inclined plate metering mechanism was designed and developed based on onion seed properties. The developed prototype was evaluated in field for its performance evaluation for direct sowing of onion seed variety *Punjab Naroya* on beds. The planter was operated at three speeds 1.5, 2.0 and 2.5 km·h^{-1} and three plate angles 26º,36º and 46º and two row spacings of 15 and 18 cm. The average seed spacing varied between 6.09-11.68 cm. Average seed spacing at 2 km/h forward speed and 36° plate angle was 7.6 cm that was closer to the required theoretical spacing of 7.5cm. The overall saving in cost and time with raised bed onion planter as compared with manual method were 57.89 % and 98.75 % respectively.

Key words*: raised bed planter, inclined plate planter, maize, germination, yield*

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INTRODUCTION

The onion is an important vegetable and has been grown in almost all the parts of India. India ranks second in area and production after China. Major onion producing states in India are Maharashtra, Karnataka, Gujarat, Rajasthan and Bihar contributing more than 50% of total production in India. Productivity of onion in India is very low about 15-16 t/ha as compared to other countries [1]. Large amount of labour is required for transplanting and the labour requirement is as high as 100-120 man days·ha^{-1} [5].

Direct sowing of onion is more economical as compared to transplanting as there is saving in labour cost and time. Planters can be used for direct sowing of onion and other row crops as it maintains both plant to plant and row to row spacing. A study was conducted on use of mechanized machinery in sowing of onion seeds. Highest productivity was at plant density of 571-714 thousand plants per hectare. Seed planted at depth of 1-2 cm ensured plant emergence by 81-91% [2].

A study was conducted to develop and test a vacuum planter for onion. The highest values of the actual seed spacing were obtained with the seed plates of 0.8 mm hole diameter at 0.08 m·s^{-1} disc speed [6]. A two row manually operated direct seeder for onion crop with inclined plate metering mechanism was developed and evaluated in the field. Seed plates with 12, 24 and 36 grooves were used. The required plant population was achieved with the plate having 24 grooves. The neck thickness, bulb weight and yield of transplanted onion were slightly higher than direct sown crop [3]. A manually operated drum seeder was developed for onion and its performance evaluation was carried out. Developed seed drum width was 60 cm for six rows with row spacing of 10 cm. The sowing time (6 h/ha) was significantly lower for drum seeder than manual line sowing (48 h/ha) which contributes to reduce the cost of sowing for direct seeded onion [4]. Inclined plate seed metering device was designed and evaluated in laboratory for singulation and uniform placement of maize and soybean seeds at three different cell shapes and sizes. The performance parameters like average spacing, multiple index, quality of feed index and precision were measured. Among the combinations of design variables, the seed metering plate with semi-circular cell shape having cell size 7 mm diameter was found to be the optimum for metering maize seed. Average spacing, quality of feed index, multiple index, miss index and precision were 17.48 cm, 79.33 %, 18.67 %, 2 % and 10.5 %, respectively. Likewise, the seed metering plate with semi-circular cell shape having cell size of 12 mm diameter was found to be optimum for metering soybean seed. Average spacing, quality of feed index, multiple index, miss index and precision were 9.65 cm, 77.33 %, 14.33 %, 8.34 % and 18.73 %, respectively. Therefore, considering all the performance parameters, inclined plate metering device with semi-circular shape of cell diameters 7 mm and 12 mm were selected for maize and soybean seeds, respectively [7].

Based upon these reviews inclined plate planter was decided to be developed with depth control provision and evaluate it in the field. The reason for selection of inclined plate planter was its lower cost as compared to vacuum seeders and precise metering as compared to drum seeders.

MATERIAL AND METHODS

The inclined plate planter was designed, developed and evaluated for Punjab Naroya onion seeds. The procedure used to perform this study has been presented as under:-

Seed properties determination: The properties of the onion seed namely, size, sphericity, thousand seed weight and germination percentage were studied in the laboratory. The three major dimensions of the seed were determined using overhead projector. Sphericity of the seeds was calculated from these measured dimensions. Thousand seed weight was determined for three random samples on an electronic balance with least count 0.001 g. Germination test was done by placing onion seeds on a moistened germination paper and then in an incubator for required temperature conditions. Germination count was taken after fourteen days and converted into percentage. Germination percentage of the seeds was 80.67 %. The measured properties are shown in Tab. 1.

Table 1. Physical properties of Punjab Naroya onion seed

S. No.	*Particulars*	*Range*
1	*Major dimension (mm)*	*2.87-3.10*
2	*Sphericity (%)*	*64.32-75.28*
3	*Thousand seed weight (g)*	*2.90-3.10*
4	*Angle of repose*	*24.12º*

Development of the metering mechanism: Based on onion physical properties obtained and desired plant to plant spacing an inclined plate was developed for onion seed and various dimensions of metering plate are shown in Tab. 2.

Table 2. The values of various variables selected for inclined plate

Parameter		*Purpose*	*Value*
Dg	*Depth of the groove*	*It should be slightly larger than the length of seed.*	*3.4 mm*
θ_g	*Opening of the groove*	*It determines the loading process of the groove.*	*3.8 mm*
β_{rs}	*The right side angle of the groove*	*It determines the ease in loading process of the groove.*	*47°*
β_{ls}	*The left side angle of the groove*	*It determines the seed holding capacity.*	*29°*

The developed metering plate for onion seed is shown in Fig. 1.

Main Frame : The functional requirement of the machine was to sow seven rows of onion on a raised bed with 1m top width. It was made up of a mild steel square section of 60x60x8 mm. It was provided with an arrangement to fix the seed box, fertilizer box, bed maker, transmissions, seeding and fertilizer furrow openers.

Seed metering mechanism : An inclined platemetering mechanism was selected for the prototype to be built. Metering plates were developed based upon the design procedure followed by Chinna (2010). The groove size and geometry was selected according to size and shape of onion seed. The more number of grooves were selected owing to closer spacing requirement of onion crop. Seed box was made from mild iron

sheet of 2 mm thickness. The length of the seed box was 1420 mm. Dimensions of the seed box are shown in Fig 2.

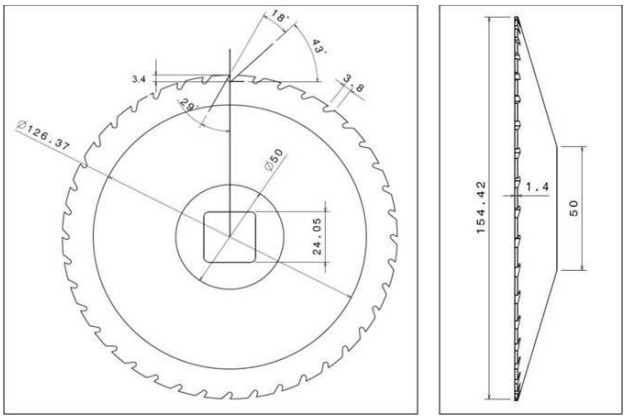

Figure 1. Front and side view of metering plate

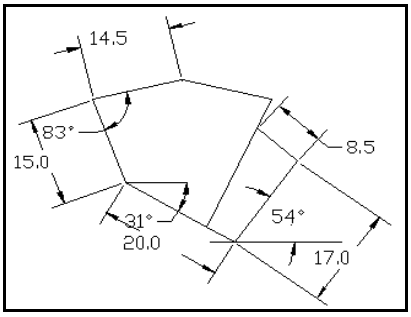

Figure 2. Seed box dimensions (cm)

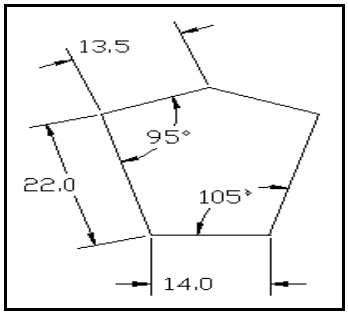

Figure 3. Fertilizer box dimensions (cm)

Fertilizer metering mechanism: The fertilizer metering mechanism was inducted in the developed onion planter to reduce the labour required for fertilizer application. Fertilizer fluted rollers made of cast aluminium were used. Trapezoidal shaped fertilizer box as shown in Fig 3 was made up from mild steel iron sheet of 2 mm thickness. The length of the fertilizer box was 1420 mm. Fertilizer box was provided with a lever to adjust the fertilizer rate.

Bed maker: A bed maker was attached having 1000 mm top width and 1400 mm bottom width. Two furrowers made up of high carbon steel were attached on both sides of the bed maker for scouring of soil to make beds. This bed maker was made from mild steel iron sheet of 3 mm thickness. This bed maker also acted as depth control device.

Furrow openers: Seven shoe type furrow openers made of high carbon steel were used to open the soil for seed placement at required depth. Plastic tubes were used to convey the seed from metering mechanism to the furrow openers. The furrow openers for seed placement were fitted behind the bed maker. The furrow openers were fitted to main frame with a mild steel strip. A slot was provided in the strip to vary the depth of

seed placement. The furrow openers spacing was kept at 150 mm and number and spacing can be varied according to other small seed crops.

Figure 4. Planter during development phase

Table 3. Specifications of the developed raised bed tractor operated onion planter

Description	*Specifications/type*	*Material of component*
Tractor HP required	*50 HP*	--
No. of rows	*7*	
Frame	*Box section frame*	*Mild steel square section*
Bed maker components shovel with wing bed maker	*Plough shape 1.0 m top bed with Triangular section furrows*	*High carbon steel Mild steel*
Seed metering mechanism	*Inclined plate*	*Aluminium*
Diameter of inclined plate (mm)	*154.42*	---
Number of grooves on inclined plate	*40*	---
Fertilizer metering mechanism	*Fluted roller*	*Aluminium*
Number of fluted rollers	*6*	---
Seed and fertilizer delivery tubes	----	*Plastic*
Furrow openers	*Shoe type*	*High carbon steel*
Depth of placement	*Adjustable with respect to bed maker*	----
Row to row spacing	*Adjustable*	----
Ground wheel	*Lugged*	*Mild steel*
Diameter (mm)	*420*	----
Power transmission for metering systems	*Chain, sprockets and bevel gear*	*Mild steel*
Speed ratio between ground wheel and seed metering plate	*3:4*	---
Overall dimensions (mm)	*1845 x 1520 x 1230*	----

Ground wheel: A lugged ground wheel made from mild steel sheet of 6 mm thickness was used to give drive to the seed and fertilizer metering mechanisms. It was

of 420 mm diameter and 90 mm width and was fitted with twelve lugs on the periphery for the positive rotation on the stubble field conditions. A spring was provided between the wheel arm and main frame to keep the wheel pressed on ground surface during the sowing operation for reducing wheel slip and missing of seed metering mechanism.

Power transmission for metering mechanisms: The power required to run the metering mechanism was provided from the ground wheel with the help of sprockets and chain. The power transmission from the ground wheel to the seed metering and fertilizer metering mechanisms is shown in Fig. 5. A fifteen teeth sprocket was used to transmit power from the ground wheel to a main shaft having fifteen teeth sprocket with the help of chain. The power from the main shaft was transmitted to the fertilizer shaft that was fitted with 24 teeth sprocket. In series the power is transmitted to the seed metering unit shaft that was fitted with set of sprockets (15, 24 and 31 teeth) to vary the speed ratio.

Figure 5. Developed raised bed inclined plate onion planter

The seed and fertilizer boxes were mounted on the planter. The height of seed drop was kept at 700 mm. Planter during development phase is shown in Fig. 4 and developed tractor operated raised bed onion planter is shown in Fig 5. The details of the different components of the developed prototype are given in Tab. 3.

RESULTS AND DISCUSSION

Field evaluation of the tractor operated onion planter : The recommended spacing for *Punjab Naroya* variety is 15 x 7.5 cm. The field was irrigated and well prepared at optimum soil moisture before sowing of onion. Then at optimum moisture direct sowing of onion seed on beds was done.

The developed planter was evaluated at three forward speeds (1.5, 2.0 and 2.5 $km.h^{-1}$) at three angles of inclined plate with horizontal (26°, 36° and 46°) for sowing of *Punjab Naroya* onion variety at 15 cm and 18 cm row spacings. The planting depth was maintained at 1.5-2.0 cm. The onion seed planter during field operation is shown in Fig. 6. The parameters like fuel consumption, forward speed were recorded. Then after germination of the onion crop the plant to plant spacing was recorded and is shown in Tab. 4. It is clear from Tab. 4 that as the planter forward speed and inclination of plate

were increased the average seed spacing also got increased. The view of germinated onion crop (variety Punjab Naroya) sown with inclined plate planter is shown in Fig. 7.

Figure 6. Onion seed planter during operaion

Figure 7. View of germinated onion crop

The statistical analysis was also done and shown in Tab. 5. The statistical data shows that effect of forward speed and plate inclination individually and combinedly was significant at 5 % level of significance.

Economic Analysis : Economic analysis of the machine was done to determine its cost effectiveness as compared to manual transplanting of the onion crop and is shown in Tab. 6 . Some suitable assumptions were made to calculate the economic viability of the developed raised bed onion planter. The seed requirement in direct sowing was 5.12 $kg \cdot ha^{-1}$ lesser than transplanting thus helps in saving of Rs 14,760 per hectare. Total cost of planting onion by machine was found to be Rs 19,944.58. In case of traditional method the nursery raising and transplanting cost was found to be Rs 47,366.75. The total saving from machine planting was *Rs* 27,422.17 per hectare.

Table 4. Average seed spacing at 15 and 18 cm row spacing

Row Spacing cm	Speed km.h^{-1}	Plate angle (°)	Average Seed Spacing (cm)			Average
			R1	R2	R3	
15	1.50	26	5.85	6.14	6.3	6.09
		36	7.44	6.13	6.81	6.79
		46	8.99	8.11	8.06	8.72
	2.00	26	5.99	5.86	7.48	6.44
		36	7.03	6.62	9.16	7.6
		46	11.04	9.43	10.24	10.24
	2.50	26	6.47	6.5	8.26	7.08
		36	8.39	8.32	8.81	8.5
		46	10.51	12.82	10.75	11.36
18	1.50	26	6.21	6.15	6.02	6.13
		36	6.83	7.12	6.96	6.97
		46	9.23	8.45	8.51	8.73
	2.00	26	6.72	6.75	5.99	6.48
		36	8.36	7.21	7.56	7.71
		46	10.04	10.16	10.4	10.2
	2.50	26	7.2	7.3	6.96	7.15
		36	8.37	8.41	8.75	8.51
		46	11.28	12.59	11.17	11.68

Table 5. ANOVA Table for effect of forward speed and angle of inclined plate with horizontal on average seed spacing

SOURCE	df	SS	MSS	F-Ratio	CD (5%)	C.V.
Factor A	1	0.1884	0.1884	0.4092	NS	
Factor B	2	31.2668	15.6334	33.9452	0.4588	
Factor C	2	117.523	58.7615	127.5904	0.4588	
A * B	2	0.0492	0.0246	0.0534	NS	
A * C	2	0.0602	0.0301	0.0654	NS	
B * C	4	6.2281	1.557	3.3808	0.7946	
A * B * C	4	0.1114	0.0278	0.0605	NS	
Error	36	16.5797	0.4605			8.3627

**A=Row spacing, *B= Forward speed and *C=Angle of inclined plate with horizontal*

Table 6. Economic analysis of the developed planter

Parameters	Method of planting	
	Inclined plate planter	Manual Transplanting
Land Preparation Cost, Rs.ha^{-1} [Disc harrow(2)+cultivator(2)+planker (1)]	6116.75	6116.75
Seed Requirement, kg.ha^{-1}	5.12	12.50
Seed cost, Rs. ha^{-1}	10,240.00	25,000.00
Nursery raising cost, Rs.ha^{-1}	--	3,750.00
Operation cost, Rs.ha^{-1}	35,87.83	12,500.00
Total cost of planting, Rs.ha^{-1}	19,944.58	47,366.75
Field capacity, ha.h^{-1}	0.20	0.0025
% saving in cost	57.89	----
% saving in time	98.75	----

CONCLUSIONS

1. An inclined plate planter was designed and developed for direct sowing of onion seed on beds.
2. The average seed spacing got increased with increase in the forward speed of the planter and increase in plate angle.
3. Average seed spacing at 2 km.h^{-1} forward speed and 36° plate angle was 7.6 cm that was closer to the required recommended spacing of 7.5cm.
4. The overall saving in cost and time with raised bed onion planter as compared with manual transplanting method were 57.89 % and 98.75 % respectively.

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KONSTRUKCIJA, RAZVOJ I TERENSKA ISPITIVANJA SADILICE ZA DIREKTNU SADNJU LUKA (*Allium Cepa* L.) U LEJE

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Sažetak: U Indiji crni luk (*Allium cepa*, L.) zauzima površinu od 1064 ha, sa proizvodnjom od 15118 hiljada tona. Izvoz luka tokom 2011 -12 bio je 13,09,863.26 hilada tona u vrednosti od *Rs* 1,722.85. Indija je drugi najveći proizvođač luka u svetu odmah posle Kine, ali prinos luka u Indiji je veoma nizak, 14.21 t.ha^{-1} u poređenju sa kinom i drugim zemljama kao što su Egipat, Holandija, Iran i dr. Indija je drugi proizvođač povrća u svetu posle Kine. Trajanje postupaka i efikasna upotreba inputa su od ključnog značaja u postizanju visokih nivoa proizvodnosti i kvaliteta. Radi povećanja

površine pod lukom i povećanja konkurentnosti i profitabilnosti proizvodnje, važno je uvoditi mehanizovane tehnologije u njegovom gajenju. Ručna sadnja i presađivanje luka je veoma skupa operacija koja zahteva mnogo rada. Zato je konstruisana sadilica sa mernom kosom pločom za sadnju luka u leje sa pogonom od traktora, na osnovu osobina semena luka. Razvijeni prototip bio je testiran u poljskim uslovima radi ocene njegovih karakteristika u direktnoj setvi luka varijeteta *Punjab Naroya* u leje. Sadilica je radila sa tri brzine 1.5, 2.0 i 2.5 km·h^{-1}, tri ugla ploče 26º,36º i 46º i dva međuredna rastojanja 15 i 18 cm. Srednje rastojanje u redu variralo je od 6.09 do 11.68 cm. Srednje rastojanje u redu pri brzini od 2 km·h^{-1} i nagibu ploče od 36° bilo je 7.6 cm, što je bliže traženom teorijskom rastojanju od 7.5 cm. Ukupna ušteda troškova i vremena sa ovom sadilicom u poređenju sa ručnom sadnjom bila je 57.89 % i 98.75 %, redom.

Ključne reči: *sadilica, sadilica sa kosom pločom, kukuruz, klijanje, prinos*

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SHORT DURATION RAINFALL FORECASTING MODELING THROUGH ANNS

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Abstract: Present research paper is articulated the application of Artificial Neural Networks (ANNs) in the field of rainfall forecasting. Research shows ability of ANNs for daily rainfall forecasting. Two Different combinations of weather parameters, one day lag and previous moving average week as case I and Case II respectively has been prepared to generate nonlinear relationship. There are single and multi-hidden layer ANNs generated by increasing and decreasing of hidden layer(s) and Processing Element (PE) by trial and error method. Developed models are selected based on mainly two basics criteria least Mean Square Error along with higher Correlation Coefficient and low Value of Akaike Information Criteria(AIC). Different models were developed and tested by using two input dataset. Models were trained and tested using last 30 (1979-2008) years and 5 (2009-13) year of weather parameter respectively. Result showed that multi hidden layer model ANN Model (7-4-1-1) of case II has good Correlation Coefficient (0.93) and least Mean Square Error (0.001) which was selected as best among four models. It clearly revealed that monsoon depends on long term of weather parameter. It unveils that it does not necessary have more number of Processing Element (PE) and more number of hidden layer(s) which always give good result. Sensitivity analysis revealed that wet bulb temperature is most sensible parameter followed by mean temperature, dry bulb temperature, relative humidity, evaporation, rainfall, and wind velocity.

Key words*: rainfall forecasting, ANN_S, previous day, moving average week, weather parameter, BPNN, validation, sensitivity*

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INTRODUCTION

Water is essential for all life. Rainfall is vital resources of fresh water. It is also one of the prime requirements for agriculture, industrial production, domestic and re-creation. Components of precipitation, resolved into soil moisture and groundwater, are the prerequisites for biomass production and social development in dry areas. Rainfall is cheap and prime source of fresh water. Per capita availability of water is reducing at alarming rate. It shows serious issue of water stress. India occupies only 3.28 million sq. km geographical area which supports 17% of the population and 20 per cent livestock population of world from 2.4 per cent of the land area and 4% of water resources of the world. The farming is the backbone of Indian agriculture contribute 14.2 per cent share in total GDP. It shows that the water is essential for growth of agricultural and allied sectors.

Artificial Neural Networks (ANNs) are biologically inspired computer programs designed to simulate the way in which the human brain processes information. ANNs gather their knowledge by detecting the patterns and relationships in data and learn (or are trained) through experience, not from programming. An ANN is formed from hundreds of single units, artificial neurons or processing elements (PE), connected with coefficients (weights), which constitute the neural structure and are organised in layers [2]. Rainfall forecasting is tough and nonlinear process. ANNs found to be better in terms rainfall predictions [16]. ANNs were applied for flood forecasting, evaporation study, rainfall runoff relationship, tide forecasting, ground water level forecasting, river stage forecasting, stream flow forecasting, drought forecasting and spring discharge [1]. ANNs have been widely used for rainfall or precipitation forecasting in monsoon season [6-7] [10] [12] [20]. Multi regression and ANNs are useful for long term rainfall forecasting using large scale climate modes [11]. Short term rainfall prediction models useful for real time flood forecasting [17]. Back propagation algorithm gave better result for river stage forecasting [18]. [21] developed FFNN ANN Model for monthly rainfall forecasting next to 5 to 10 year in Johor state, Malaysia. Rainfall becomes more precise where the Rainfall is main source of water for Indian agriculture where 68 % (86 Mha) of a total land are under rainfed area. Contribution of Rainfall in the month of June, July and September is decreasing for few sub-divisions while increasing in August for other subdivision in India. Many researchers have developed accurate rainfall prediction models by artificial neural networks since last decade [8]. On an average, the rainfed regions in India such as Western Rajasthan, eastern Rajasthan, Gujarat, western Uttar Pradesh, Tamil Nadu, Kashmir and Andhra Pradesh are most vulnerable to droughts, suffering once in every three years [16] where rainfall forecasting become more important.

MATERIAL AND METHODS

The study area is the Udaipur city of Rajasthan, India located at latitude and longitude 24°58'*N* and 73°68'*E*, respectively. The elevation of gauging station is at 598 m above the mean sea level.

Data acquisition and pre analysis. The depth of rainfall and its distribution in the temporal and spatial dimensions depends on many variables, such as pressure,

temperature, wind speed and direction [10]**.** Model improved forecasting monthly flow of the Mississippi River in USA by providing proper inputs [15]. Meteorological data (i.e. Wet bulb Temperature, Dry bulb Temperature, Relative Humidity, Wind Velocity, Mean Temperature, Evaporation and Rainfall) collected for the period from the month May 25th to October 30th for the year 1979 to 2013 were subjected to Pre-analysis and formulation of the data base. Thus the total number of data for each year's period comes out to be 153. Data from 1979-2008 were used to formulate and validate and data from 2009-13 were used to forecast and check the error. Weather data has been collected from weather observatory station of College of Technology and Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur.

A neural network is characterized by its architecture that present the pattern of connection between nodes. The architecture of an ANN is designed by weights between neurons, a transfer function the controls the generation of output in a neuron and learning laws that define the relative importance of weights for input to a neuron. The architecture of ANN is classified into two types: single hidden layer and multi hidden layer. Fig. 1 and Fig. 2 are Single Hidden layer and Multi Hidden Layer respectively.

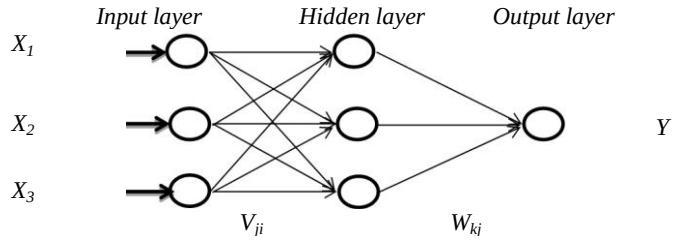

Figure 1. Single idden layer in neural Network

As shown in Fig. 1, X_1 and X_2 represent the inputs of the network, and the connection between the neurons, represented by lines, is quantified by their weights, which are shown in the V_{ji} and W_{kj}, and Y is the output from single hidden layer ANN.

In the Fig 2, inputs are shown by X_1, X_2 and X_3 and V_{ji} represents the connection weight from the jth node in the preceding layer to ithnode. 'Y' is the observed output of the network.

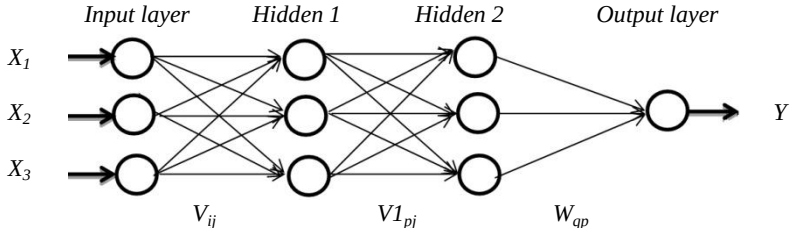

Figure 2. Multi Hidden layer(s) neural Network

Back-propagation training algorithm. Back-propagation training algorithm is the most commonly used supervised algorithm for training the multi hidden layer ANN [18]. An ANN which used back-propagation algorithm for its training is also called back-propagation ANN. In back-propagation ANN, information is processed in the forward

direction from the input layer to the hidden layer(s) and then to output layer. The objective of a back-propagation network is to find the weights that approximate target values of output with a selected accuracy. The least mean square error method, along with the generalized delta rule, is used to optimize the network weights in back-propagation networks. The gradient descent method along with the chain rule of derivatives is employed to modify the network weights. It requires a continuous, differentiable and non-linear function on the ANN to compute output from each neuron.

The input data are multiplied by the initial weights, then the weights inputs are added by simple summation to yield the net input to each neuron.

$$Net = \sum_{i=1}^{N} V_{ji} X_i \tag{1}$$

where:

X_i [-] - input to any neuron,
V_{ji} [-] - weighted matrix from j^{th} layer to i^{th} layer,
N [-] - number of inputs,
Net [-] - net for j^{th} neuron.

The net of neuron is passed through an activation or transfer function to produce output form a neuron.

$$O = \frac{1}{1 + \exp(-Net)} \tag{2}$$

where:

O [-] - output signal form i^{th} neuron.

After error between the output of the network and the target output are computed at the end of each forward pass, and is summed over as follows:

$$E = \sum_{i=1}^{N} \frac{1}{2} (O_i - D_i)^2 \tag{3}$$

where:

E [-] - total error,
O_i [-] - observed output,
D_i [-] - target output.

The weight values are originally initialized randomly for all the connection weights in the network. During the back-propagation of error signal at output neuron, the weights are modified according to the following equations:

$$V_{ji}(n+1) = V_{ji}(n) + \Delta V_{ji}(n) \tag{4}$$

$$\Delta V_{ji}(n) = \eta(\delta_i)(O_j) + \alpha \Delta V_{ji}(n-1) \tag{5}$$

where:

$\Delta V_{ji}(n)$ [-] - change in weight V_{ji} at n^{th} iteration,
$\Delta V_{ji}(n-1)$ [-] - change in weight V_{ji} at $n\text{-}1^{th}$ iteration,
$V_{ji}(n)$ [-] - weight V_{ji} at n^{th} iteration,
$V_{ji}(n+1)$ [-] - updated value of weight V_{ji} at (n^{th}) iteration,
O_j [-] - output from j^{th} neuron in the output layer,

α [-] - momentum constant,
η [-] - learning constant.

The value of δ_i for output neuron is given by:

$$\delta_i = O_i(1 - O_i)(D_i - O_i) \tag{6}$$

where:
O_i [-] - output from the network,
D_i [-] - target value of the output,
δ_i [-] - error signal term of the output layer.

In the output layer, the target outputs are known, in the hidden layers, target values are not known. Therefore, the back-propagation algorithm uses the sum of the error signals of all the neurons of the succeeding layers to calculate error signals of any neuron 'j' in the hidden layer.

$$\delta_i = O_i(1 - O_i) \sum_p \delta_p W_{qp} \tag{7}$$

Where p runs over all the neurons in the subsequent layers and $\delta_p$in the error signal term corresponding to subsequent layer of p. The value of δ_i is then substituted in the Eq. 5. This procedure is repeated until the selected accuracy is achieved.

Activation function. The output from a neuron is calculated through the use of an activation function. The basic characteristics of the sigmoid function are that it is continuous, differentiable and is monotonically increasing. The sigmoid function is shown in Fig. 3.

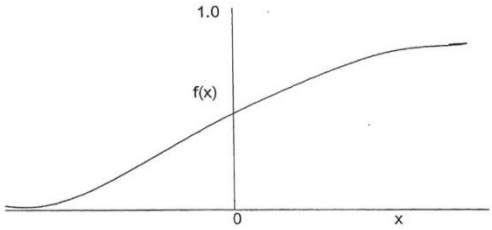

Figure 3. Sigmoid function

The sigmoid function can be represented by the following equation.

$$f(x) = \frac{1}{1 + exp\,(-ax)} \tag{8}$$

where:
a [-] - slope parameter.

The output from sigmoid function is always bounded within 0 to 1 and input to the function can vary between $-\infty$ to $+\infty$.

The most popular and successful technique for selecting the appropriate number and size(s) of the hidden layer(s) is trial and error method. A number of networks with one or two hidden layers are trained with different combinations of hidden neurons and a network is selected that yields the minimum Mean Square Error (MSE) and maximum

Correlation Coefficient (CC). It is important that the size of the network should be small as possible.

Development of ANNs Model Single & multi hidden layer(s) Neural Network Case I & Case II: In this case the observed time series of Wet bulb Temperature, Dry bulb Temperature, Relative Humidity, Mean Temperature, Evaporation, Wind Velocity and Rainfall of previous days and previous moving average week were taken as the input variables in case I and Case II respectively and current day rainfall as the output variable for both case I and Case II for single and multi-hidden layer(s). Levenberg–Marquardt learning algorithm and sigmoid logistic activation function have been used for prediction of annual precipitation [4]. Let the observed values of wet bulb temperature, dry bulb temperature, mean temperature, relative humidity, wind velocity, evaporation and rainfall represented as $Tw_{i,j}$, Td_{ij}, $T_{i,j}$, $RH_{i,j}$, $V_{i,j}$, $E_{i,j}$ *and* $P_{i,j}$ respectively for j^{th} day of the i^{th} year *(i = 1,2,….,M and j = 1,2,…,N).*

The functional form of the models can be represented as:

$$P_{i,j} = f(Tw_{i,j-1}, Td_{i,j-1}, T_{i,j-1}, RH_{i,j-1}, V_{i,j-1}, E_{i,j-1}, P_{i,j-1}) \quad (9)$$

Sensitivity analysis were carried by adding and removing weather parameter one by one then model were formulated and validated for the best identified model ANN (7-4-1-1). Performance evaluations of the models were carried through visual observation based on the graphical comparison between observed and predicted values of rainfall. There were also statistical and hydrological indices used for testing the goodness of fit for comparison between observed and predicted values of rainfall.

RESULTS AND DISCUSSION

There were so many Artificial neural network generated for case I and case II, out of them only four best model were shown for each case having highest correlation coefficient (cc) and lower Mean square error (MSE) value as given in table 1.

Table 1. Performance evaluations of developed ANNs Models during training & testing period

Performance indices	*Case I (One day ahead)*				*Case II (Moving average week)*			
	Training		*Testing*		*Training*		*Testing*	
	7-12-1	*7-6-6-1*	*7-12-1*	*7-6-6-1*	*7-11-1*	*7-4-1-1*	*7-11-1*	*7-4-1-1*
MSE	*0.009*	*0.004*	*0.003*	*0.001*	*0.007*	*0.005*	*0.002*	*0.001*
NMSE	*0.62*	*2.69*	*0.54*	*0.68*	*0.15*	*0.35*	*0.39*	*0.29*
CC	*0.84*	*0.82*	*0.81*	*0.80*	*0.92*	*0.94*	*0.90*	*0.93*
AIC	*-31715*	*-24845*	*-4819*	*-4965*	*-30625*	*-27114*	*-4914*	*-5096*
MDL	*-31545*	*-24480*	*-4754*	*-4847*	*-30444*	*-27003*	*-4762*	*-4923*
% ERROR	*52.15*	*24.14*	*36.18*	*22.12*	*66.87*	*51.40*	*39.69*	*36.09*
CE	*83.55*	*85.60*	*80.65*	*79.75*	*92.59*	*96.74*	*86.62*	*88.45*
EV	*26.15*	*28.94*	*17.14*	*18.05*	*15.40*	*13.06*	*8.42*	*5.34*

Qualitative performance was carried through Statistic Indices and Hydrologic indices. Statistics indices and hydrologic indices shows network 7-4-1-1 as best model

(CC 0.93 and MSE 0.001) followed by 7-11-1 (CC= 0.90 and MSE=0.002), 7-12-1 (CC=0.81 and MSE=0.003) and 7-6-6-1 (CC=0.80 and MSE= 0.001). The network 7-4-1-1 shows 7 inputs, 4 Neurons (processing elements) for first hidden layer, 1 neuron for second hidden layer and 1 output (Rainfall). Value of different statistics indices like Mean Square Error (MSE), Normalise Mean Square Error (NMSE), Correlation Coefficient (CC), Akaike's Information Criterion (AIC) and Minimum Description Length (MDL), Percent Error (% ERROR) and value of Hydrologic indices Volumetric error and Coefficient of Efficiency (CE) of different ANNs were as given in the table 1.

The Fig. 4 shows that there is close agreement between Observed and Predicted Rainfall of ANNs network of 7-4-1-1 followed by 7-11-1, 7-12-1 and 7-6-6-1 of case I and case II respectively during the testing period (2009-2013).

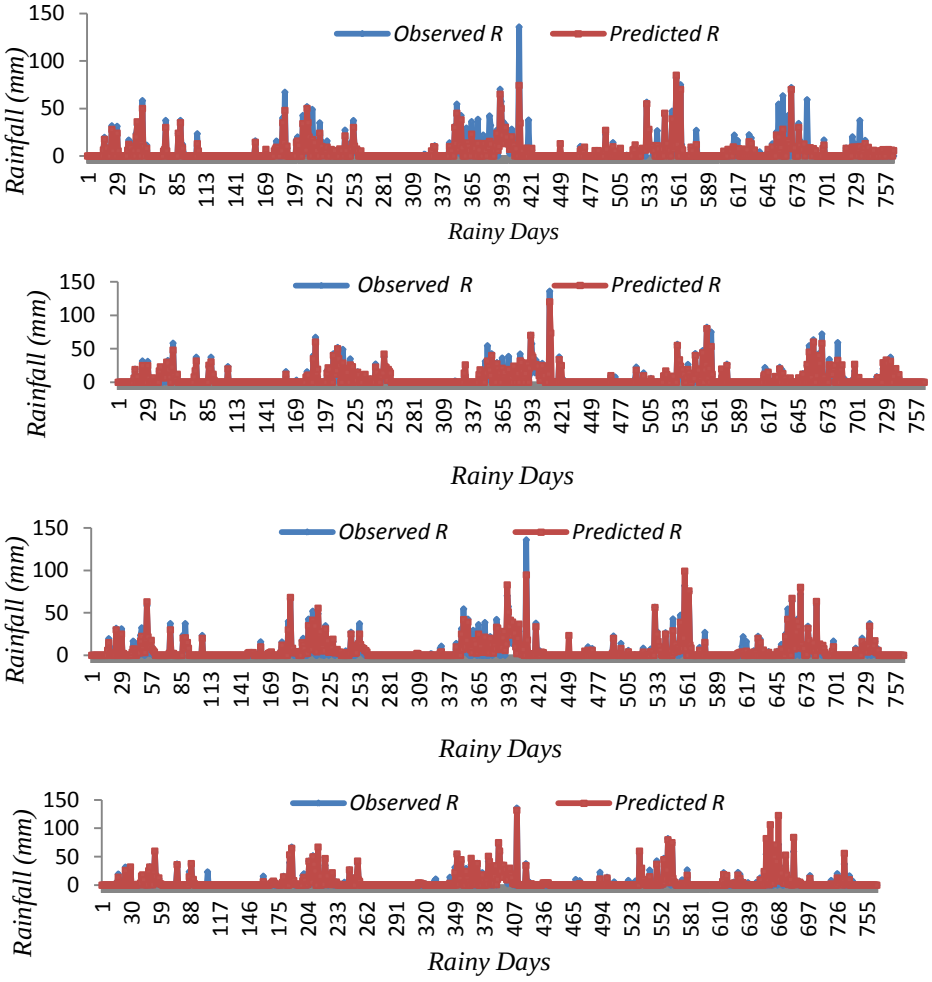

Figure 4. Observed and Predicted Daily rainfall of ANN model 7-12-1,7-6-6-1, 7-11-1 and 7-4-1-1 (top to bottom) during for testing period (2009-13)

It revealed that Rainfall forecasting is carried through previous moving average week weather parameter gives good result as compare to that of previous day. So occurrence of rainfall depends on long term weather parameter. Sensitivity was carried out for the Best ANN model 7-4-1-1 as shown in fig. 5. It shows that Wet bulb Temperature is most sensible parameter followed by Mean Temperature, Relative Humidity, Dry bulb Temperature, Evaporation, Rainfall and Wind Velocity.

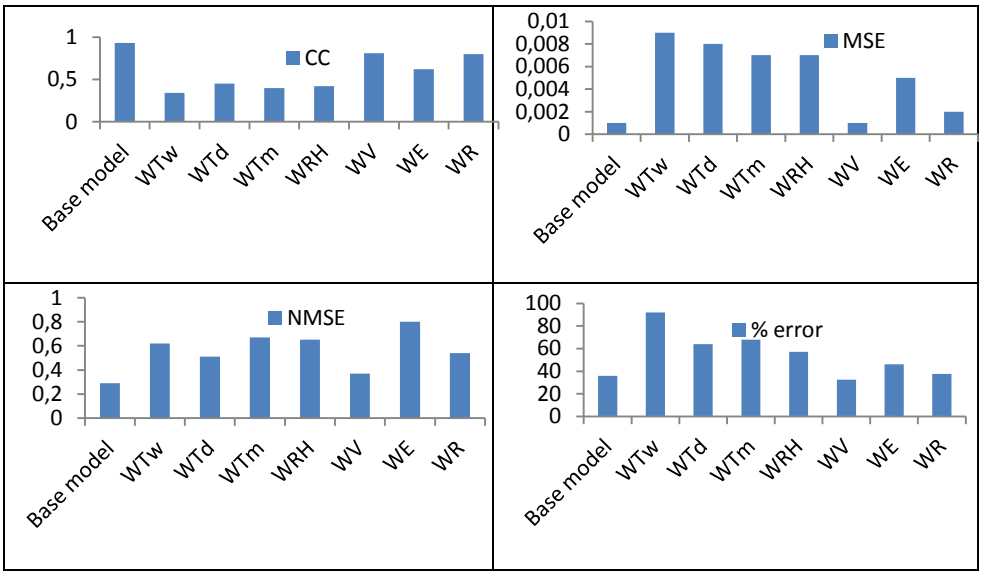

Figure 5. Performance of sensitivity analysis of base ANNs (7-4-1-1) model

CONCLUSIONS

Based on the performance indices of Artificial Neural Networks (ANNs) 7-4-1-1and 7-11-1 show better than networks 7-6-6-1, 7-12-1 of single and multi-hidden layer of case II and case I respectively. It clearly indicates that the rainfall forecasting depends on long term weather parameter. It also noted that more number of Processing Element (PE) and higher number of hidden layer does not give always best result. Sensitivity analysis of Artificial Neural Network 7-4-1-1 revealed that Wet bulb Temperature is most sensible parameter followed by Mean Temperature, Relative Humidity, Dry bulb Temperature, Evaporation, Rainfall and Wind velocity. Visual observation, statistical and hydrological indices were showed that ANN (7-4-1-1) can be useful for rainfall forecasting for Udaipur.

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KRATKOROČNA PROGNOZA PADAVINA MODELIRANJEM KROZ ANNS

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Sažetak: U radu je predstavljena aplikacija Veštačke Neuronske Mreže (ANNs) u oblasti prognoze padavina. Istraživanje pokazuje mogućnost ANNs za dnevnu prognozu padavina. Dve različite kombinacije vremenskih parametara, jednodnevni pomak i prethodna pokretna srednja nedelja kao Slučaj I i Slučaj II, redom, bile su pripremljene da se generiše nelinearna zavisnost. Postoje jedan i više skrivenih slojeva ANNs generisanih povećanjem i smanjenjem skrivenih slojeva i Elementom za obradu (PE) metodom probe i greške. Razvijeni modeli su izabrani na osnovu dva kriterijuma, najmanja srednja kvadratna greška zajedno sa koeficijentom korelacije i kriterijumom donje vrednosti Akaike informacije (AIC). Različiti modeli su razvijeni i testirani upotrebom dva ulazna seta podataka. Modeli su isprobani i testirani upotrebom poslednjih 30 (1979-2008) godina i 5 (2009-13) godina vremenskih parametara, redom. Rezultat je pokazao da je model više skrivenih slojeva ANN Model (7-4-1-1) slučaja II imao dobar koeficijent korelacije (0.93) i srednju kvadratnu grešku (0.001) i bio je izabran kao najbolji od svih modela. Jasno je pokazao da monsun dugoročno zavisi od vremenskih parametara. On otkriva da ne mora da ima veći broj elemenata obrade (PE) i veći broj skrivenih slojeva koji uvek daje dobar rezultat. Analiza osetljivosti pokazuje da je temperature vlažnog termometra najosetljiviji parameter, a za njim sledi srednja temperatura, temperatura suvog termometra, relativna vlažnost, evaporacija, padavine i brzina vetra.

Ključne reči: *prognoza padavina, ANN_S, prethodni dan, prosečna nedelja, vremenski parameter, BPNN, validacija, osetljivost*

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INVESTIGATION OF NOISE PARAMETERS AT HEAD THRESHER OPERATION AND NOISE MAP DEVELOPMENT IN FREE SOUND FIELD

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Abstract: The article demonstrates the need to solve the problems connected with adverse acoustic impact on small tools and equipment operators of selective and seed-production process in plant breeding. Assessment method of the overall area of hazardous values of equipment noise characteristics in similar conditions and specialized device for carrying out acoustic research are described. The method to do research and to compile two-dimensional noise map by the example of head batch thresher is developed.

Key words*: noise characteristics, safety, head thresher, means of individual protection, professional diseases, small tools and equipment, noise audiometer-analyzer, measuring face, noise map*

INTRODUCTION

It is known that, excessive noise at long-term effect can result in workers' professional diseases, for example, occupational deafness. Excessive noise level effect during the working process is the cause of hearing loss in 16% of all cases. Besides, excessive noise level can increase workers' injury risk at the sake of decreasing the possibility of acoustic hazard assessment [1-3].

Under current conditions, the problem of noise impact on workers is considered by many leading experts and scientists. One of the activity spheres that are under investigations is agriculture where noise produces considerable impacts on personal.

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But if for “big” mechanization of the production processes in plant breeding and cattle breeding the noise influence on workers is studied sufficiently detailed when utilizing small tools and equipment this influence requires further investigation. Thus, in selective and seed-production process (SSP) at relatively small quantities of the obtained samples and strict requirements to the quality of the performed operations small-sized and specialized machinery and equipment that can do sufficient noise impact on operators are used.

It is known that, different threshing devices belong to the machine types with the excessive noise level at operation. This is explained with their constructive peculiarities (the presence of belt driving, pulleys, rotating threshing drums, separator fans) and the method of influence on the processed material (shock action, friction processes between working elements and vegetal mass, separation of grain and non-grain part), and their utilization conditions.

For example, if at the Ist stage of SSP for separate plants threshing tabletop threshers with manual or mechanical drive (their noise impact level on operator varies from 40 to 65 dB) are used or plants are threshed manually, then at the II nd stage plant threshing is done in portable small-sized threshers with noise achieving 80 dB and more. At the III rd and the IV th stages of SSP bunch and sheaf threshers are used (70…120 dB, that is more than maximum acceptable level (MAL) 80 dB), and also grain combine harvesters of selective and selective and seed-production purpose are used. The noise impact level in their cabins can exceed 90 dB.

It is important to emphasize that low batch sizes of the tested material are processed in the closed laboratory conditions. At that, the noise spreading process indoors has its peculiarities being characterized with multiple reflections of acoustic waves from walls and different objects that are located in the working range and wave overlapping and increasing noise impact correspondingly. Except noise impact on machine operators using standard protective means, the influence is produced on other workers who are in the same room and are occupied with other job types.

To solve these problems the task to investigate free acoustic wave distribution and their frequency characteristics generated by one of the small tools and equipment means heavily used in SSP was formulated. As the result of this work we plan to reason methodology and develop guide lines to compile noise maps for the industrial noise sources. The last ones allow modeling acoustic waves spreading in laboratory closed space and starting to realize the complex of organizational measures and engineering and technical solutions directed to decrease the level of negative impact of industrial noise on workers.

MATERIAL AND METHODS

Researches were carried out on specially allotted territory of Federal State Budgetary Educational Establishment of Higher Education Orel State Agrarian University, using well-known and authentic testing equipment and methods.

The research object was noise level impact on workers. The research subject was head thresher MKS-1M (MKC-1M) utilized in SSP for threshing of separate spikes and grain crop bunches distinguishing light impurities. The basic technical thresher characteristics are presented in Tab. 1.

The recommendations on determining noise characteristics of noise sources in free sound field above sound-reflecting surface listed in GOST 12.1.026-80 are used as the main method [5]. To study noise level dependence from distance in the open space the individual method was developed.

Table 1. Technical characteristics of thresher MKS-1M (MKC-1M) [4]

Efficiency per hour, plants	*320*
Total capacity of electromotor [kW]	*0,25*
Rotational frequency [min^{-1}]: *- drum* *- fan*	 *1000;1300;1600* *3400*
Drum diameter [mm]	*194*
Changeable concave number	*3*
Mesh size of concaves [mm]	*6×32; 4×25; 3×20*
Overall dimensions [mm]	*570×330×485*
Mass [kg]	*21,3*

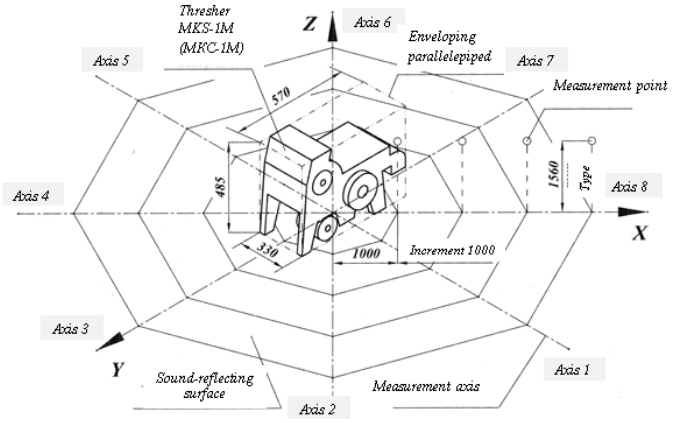

Figure 1. Scheme of measurements procedure

Thresher noise impact study was carried out in an exposed position excluding any obstacles and acoustic wave reflection. Eight axes were determined relatively noise source (Fig. 1), measurements were done in their direction. Each axis was divided into ten points in increments of one meter. Height from floor level in each point was chosen 1560 mm, which approximately corresponds to ordinate of adult acoustic analyzer position, according to anthropometric measurements in ergonomics [6].

Measurements were carried out at the thresher steady operating mode not less than in triplicate. The prepared bunches of winter wheat "Moskovskaya 39" were used for threshing. Drum rotational frequency was 1300 min^{-1}. Method of cluster analysis was used to compile a noise map, to arrange the empirical data in comparatively uniform groups [7].

Color scheme of the noise map is suggested by analogy with traditional one in similar investigations [8]. Color range corresponded to the obtained groups of noise levels in the coded units (Tab. 2).

Study of influence of distancing from noise source on its level in frequency ranges was carried out by means of correlation analysis method. Noise index measurements were done by spectra noise audiometer-analyzer "Oktava - 101 AM".

The device is intended to measure mean-root-square, equivalent and peak sound levels, acoustic pressure levels (SPL) in octave and one-third octave, to provide evaluation of noise influence on a person in industries, in dwelling and public buildings, to determine acoustic characteristics of mechanisms and machine and also scientific researches. Accuracy class: 1, according to GOST 17187 (IEC 61672-1) [9].

Measurement range: 16...146 dBA, mean-root-square levels of acoustic pressure in octave frequency band 31,5…16000 Hz. Measurement error of noise audiometer in standard environment does not exceed ± 0,7 dBA.

Table 2. Color codes of noise levels groups

№ of group	*Intervals of numerical series*	*Color code*	
		Linguistic meaning	*Color designation*
1	*70…71,12*	*green*	
2	*71,12…72,24*	*bright green*	
3	*72,24…73,36*	*yellow*	
4	*73,36…74,48*	*orange*	
5	*74,48…75,6*	*red*	
6	*75,6…77,1*	*brown*	

RESULTS AND DISCUSSION

On the carried out research ground, two dimensional noise map of head thresher MKS-1M (MKC-1M) is obtained in free sound field (Fig. 2). Apparently, the used color range and accepted intervals of measurement point spacing give full visualization of distributional pattern of acoustic waves and acoustic pressure values in different operating space zones, nearby operated equipment.

It is obvious from the noise map that acoustic wave distribution along axes of measurements is not uniform. Acoustic pressure level shifting in the area of axes 1, 2, is explained by the location of electromotor with basic mechanism drive and thresher separator fan in these areas. On the contrary, screening effect of housings of threshing and centrifuged device and machine side panels decreases considerably noise level in the direction of axes 3…8.

Thus, it is obvious that noise maps of separate units of mechanized equipment allow optimizing their arrangement in laboratory, considering decrease of adverse impact on personnel. Sound field modeling of the entire equipment complex indoors will provide an obvious picture of areas of direct and reflected sound, their combined action; provide the opportunity of predictive estimate of noise dose, obtained by personnel, analytical justification of acoustic pressure level decrease by means of utilization in laboratories the acoustic absorption means and individual protection means.

Finally, it will allow creating the most comfortable labor conditions at the workplaces, increasing labor productivity of workers, involved in selective and seed-production process, in the manufacturing process and testing new varieties of agricultural crops.

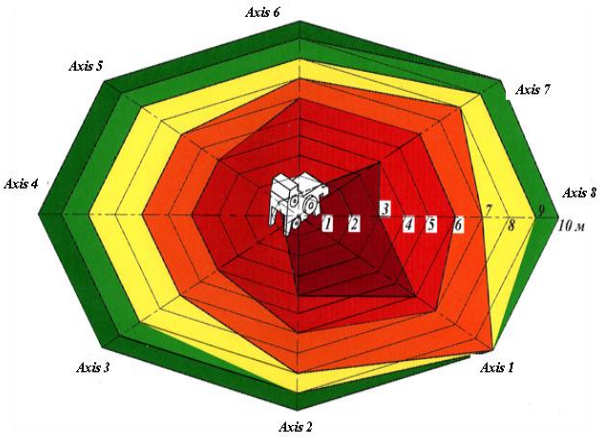

Figure 2. Two dimensional noise map of head thresher MKS-1M (MKC-1M)

CONCLUSIONS

1. Concerning labor conditions selective and seed-production process is one of the most underexplored branches of agriculture. Workplace noise connected with utilization of small tools and equipment is a real threat to workers' health;

2. Sound field mapping of the entire laboratory equipment complex is suggested to be used for effective solution of problems on decreasing of noise impact on scientific laboratory workers;

3. The method of investigation and compilation of two dimensional noise map, by the example of head thresher MKS-1M (MKC-1M) is developed;

4. The results of methodical experiment has allowed to establish that acoustic wave distribution along the axes of measurements is not uniform, which is explained by noise source arrangement and screening effect of thresher separate constructive components. The maximum value of equivalent level of thresher sound in operating mode is 81,2 dBA, the minimum value – 70,0 dBA. The intensity of acoustic pressure level decrease in frequency band on an average is 0,3…0,4 dBA, per 1 m of the length of distancing from noise source. At rather high equivalent sound level for low frequencies, its intensity at distancing from noise source, in the given band, is less than for high and medium frequencies;

5. Being carried out on the ground of noise map complex utilization, optimization of mechanized laboratory equipment arrangement will allow creating the most comfortable labor conditions, decreasing adverse noise impact on workers, increasing labor productivity, accelerating development of new progressive national varieties of agricultural crops.

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ISPITIVANJE PARAMETARA BUKE PRI RADU VRŠALICE I RAZVOJ MAPE BUKE U POLJU SLOBODNOG ZVUKA

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Sažetak: U radu je predstavljena potreba rešavanja problema povezanih sa štetnim uticajem buke na rukovaoce malih alata i opreme za proizvodnju semena. Opisani su metod procene opšte oblasti opasnih vrednosti karakteristika buke ispitivane opreme u sličnim uslovima i specijalizovani uređaji za izvođenje akustičnih ispitivanja. Razvijen je metod ispitivanja i sastavljanja dvo-dimenzionalne mape buke kroz primer vršalice.

Ključne reči: *karakteristike buke, sigurnost, vršalica, sredstva za ličnu zaštitu, profesionalne bolesti, mali alati i oprema, merač-analizator buke, merna površina, mapa buke*

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EFFECT OF SOAKING AND STEAMING PARAMETERS ON MILLING QUALITY OF PADDY (CV. *MTU 1075*)

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Abstract: The effect of soaking and steaming parameters on the milling characteristics of paddy (Cv. *MTU 1075*) was studied at different initial moisture contents. Soaking was carried out at different temperatures of 40 to 80°C. Soaking was also carried out at three elevated pressures viz. 2.0, 4.0 and 6.0 kg·cm^{-2} absolute pressure at the soak water temperature of 70°C. Steaming was carried out at 0.5, 1.0, 1.5, 2.0 and 2.5 kg·cm^{-2} absolute pressures. It was observed that the increase in the soak water temperature as well as the pressure of soaking improved the milling quality of paddy with higher head rice yield ratios and reduced white bellies. Soaking at 80°C however reduced the head rice yield when soaked beyond 120 min. During soaking under pressure, there was difference in the head rice yield initially up to about 10 min of soaking, the difference diminished as the soaking time was increased beyond that. The maximum head rice yield was obtained with the processing at steam pressure of 1.5 kg·cm^{-2} for 12.5 to15 min. Only soaking under hydrostatic pressure also improved the yield of rice for all the conditions.

Key words*: soaking, steaming, white belly, head rice yield, milling quality, hydrostatic pressure*

INTRODUCTION

Parboiling is defined as the hydrothermal treatment to paddy grain to improve its quality. The usual parboiling method involves three steps as soaking of paddy in water,

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steaming the saturated and soft paddy and then drying the steamed paddy [1]. The time for soaking and steaming has been standardized for quality product. Among other advantages, one major benefit obtained by parboiling is the gelatinization of starch and improvement in the milling yield. The different common parboiling methods as the CFTRI method involves a processing time of 6 to 8 hours. The amount of steam consumption is also about 200 kg per tonne of paddy [2]. Alternate paddy parboiling methods without the use of steaming have also been studied with the objective to reduce the energy consumption and initial investment [3-7]. A recent development involves double steaming; the first steaming is used to heat the paddy, second steaming is used for gelatinization of paddy [2]. However, the temperature of gelatinization and the duration of parboiling depend on the variety of paddy. It could be possible to eliminate the steaming method and cause gelatinization of starch by hydrostatic pressure soaking only.

It was observed that the pneumatic pressure parboiling method could eliminate the white bellies and reduced the milling yield for paddy Cv. Parijata[6]. However, the effects would be different for different varieties of paddy. Hence, it was planned to study the extent of gelatinization during soaking at atmospheric pressure and at elevated pressures of paddy (Cv. *MTU 1075*) to assess the feasibility of eliminating the steaming process during parboiling. Only steaming was also carried out at different moisture contents of the grain to observe the degree of gelatinization at different pressures. The effectiveness of the above conditions on milling quality of paddy was also studied to decide the optimum processing conditions for the tested variety. The results of the study could help in developing alternative parboiling techniques for paddy involving less process time, energy and with acceptable milling quality. The diffusion coefficient of the paddy variety MTU 1075was also studied and observed to follow Arrhenius type relationship. The diffusion constant and activation energy were found out to be 0.01345 m²/min and 35.19 kJ/g-mole, respectively [8].

MATERIALS AND METHODS

The paddy variety *MTU 1075*, which is a widely cultivated variety of the region, was used for the study. It is a slender variety of paddy and the average length, breadth and thickness were found out to be 5.74±0.084 cm, 2.1±0.224 cm and 1.84±0.089 cm. The effect on gelatinization and milling quality of paddy was observed as affected by soaking at different temperatures and pressure levels, and steaming at different pressure levels.

For the soaking experiments, paddy was soaked at water temperatures of 40°, 50°, 60°, 70° and 80°C at three initial moisture levels. Freshly harvested paddy was dried under shade for different times to attain the desired moisture levels. The actual moisture contents were determined just before the start of the experiments. The change in moisture content of paddy during soaking was recorded to determine the rate of moisture absorption and final moisture contents. The hydrostatic soaking of paddy was continued for 6 h at 2.0, 4.0 and 6.0 $kg \cdot cm^{-2}$ hydrostatic pressure levels and at a constant temperature of 70°C at three initial moisture levels. The samples were then shade dried till the final moisture content of 16 g per 100 g dry matter for subsequent studies on the degree of gelatinization and milling quality. Similarly the extent of parboiling by steaming was observed by employing five levels of steam pressure, viz. 0.5, 1.0, 1.5, 2.0

and 2.5 kg·cm^{-2} and the duration of steaming was kept as 25 min. In this case also the initial moisture was maintained at three levels.

To analyze the extent of gelatinization, the percentage of white bellies in rice for different durations of soaking, steaming and hydrostatic treatments were experimentally determined by the principle of refraction of light by keeping samples on an illuminated work board [6]. One hundred rice grains were collected randomly after polishing the samples and were used for the analysis. The raw rice grains and grains containing opaque centre were considered to be having white bellies. Only fully translucent kernels with no white core were considered to have been properly gelatinized.

The milling studies were conducted with the help of laboratory model Satake rice sheller, polisher and length grader. The clearance between the rollers in the sheller was so adjusted that not more than 5% remained unshelled after two passes. The brown rice was then polished for one minute in the polisher and then graded. Percent head rice was calculated on the basis of initial paddy weight. Head yield ratios were calculated relative to raw paddy sample. The milling quality was presented as head yield ratio, which was defined as:

$$\text{Head yield ratio} = \frac{\text{Head rice yield obtained from the sample}}{\text{Head rice yield obtain from control (raw paddy)}} \quad (1)$$

RESULTS AND DISCUSSION

White bellied kernels. Proper gelatinization of the grain indicates the absence of white bellies. Thus the presence of white bellies in the grain kernels after the soaking and steaming operations were determined. Fig. 1 shows the percent of white-bellied kernels obtained after soaking at different temperatures under atmospheric pressure. The amount of white bellies reduced with increase in soaking temperature as well as the duration of soaking. The initial moisture content did not affect the final extent of gelatinization. However, it was observed that the white bellies could not be completely eliminated even after soaking up to 6 hours at temperatures at or below 70°C. It was attributed to the reason that the gelatinization temperature was not achieved. The white bellies were completely eliminated after 5 hours of soaking at a temperature of 80°C.

Fig. 2 shows the percent white bellies-vs-soaking time at different hydrostatic pressures. In this situation, the duration of soaking, initial moisture content and hydrostatic pressure, all affected the extent of white bellies. The increase in hydrostatic pressure resulted in more elimination of white bellies. It was possible to eliminate the white bellies completely by soaking paddy in 70°C soak water under hydrostatic pressure of 6.0 kg·cm^{-2} for 6 hours.

The steaming operation effectively reduced the white bellies and the extent of reduction was affected by initial moisture content, duration of steaming as well as pressure of steaming (Fig. 3). White bellies could not be completely eliminated at steaming pressure of 0.5 kg·cm^{-2} even by increasing duration of steaming up to 30 minutes and with increase of initial moisture content. As the presence of white bellies decreased with increase in initial moisture content and steaming pressure, paddy with higher initial moisture contents (say more than 24 g per 100 g dry matter) could be parboiled successfully by exposing it to steam pressure of 1.5 kg·cm^{-2} for only 15 min.

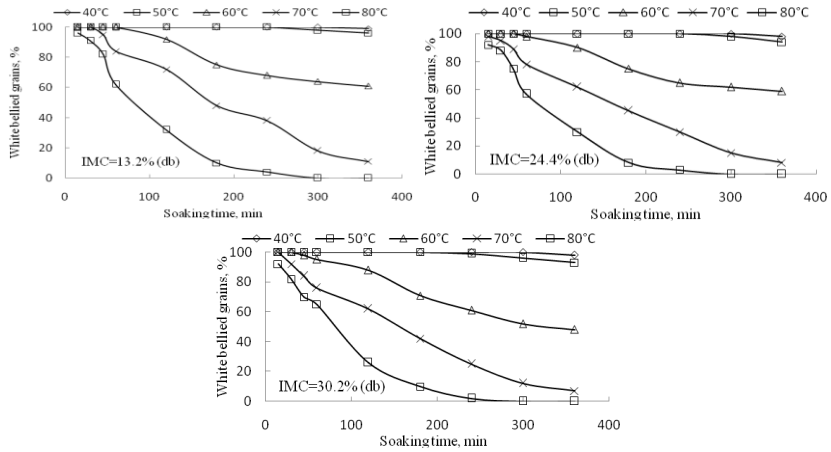


Figure. 1 Effect of soaking paddy at different temperatures on the presence of white bellies (IMC: initial moisture content)

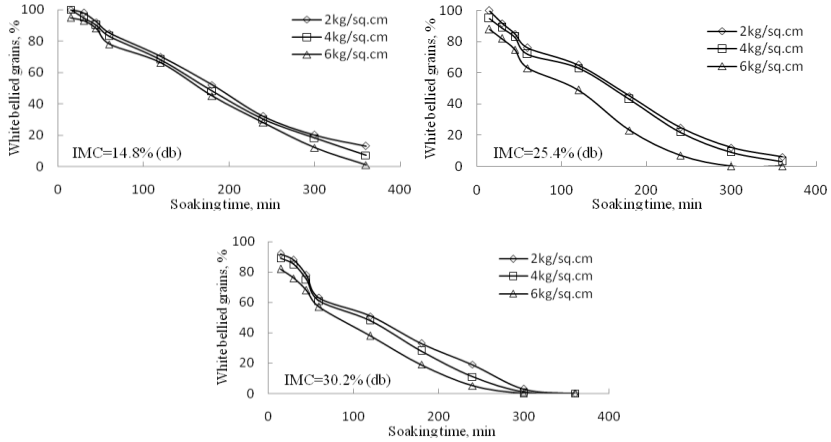


Figure. 2 Effect of hydrostatic pressure on the presence of white bellies (IMC: initial moisture content)

Head rice yield. Figure 4 shows the head yield ratios obtained for different soaking treatments. The average head rice yield obtained for the raw sample (control) under similar milling conditions was 62.4±1.6%. The head yield of rice simply soaked at atmospheric pressure was lower than that for the control sample for short durations of soaking. The head rice yield increased with increase in initial moisture content as well as the temperature of soaking. Soaking at 70°C for more than 60 min yielded higher head rice yield as compared to other low temperature soaking treatments. The head rice yield also increased for paddy soaked at 80°C for short duration; however, prolonged soaking at 80°C resulted in more breakage, which could be attributed to more softening of granules.

Fig. 5 shows the yield of rice obtained under pressure soaking, which signify that the head rice yield increased with increase in initial moisture content, duration of soaking and increase of soaking pressure. In general soaking under pressure resulted in more head rice yield as compared to soaking at atmospheric pressures. Thus pressure soaking caused gelatinization of the starch.

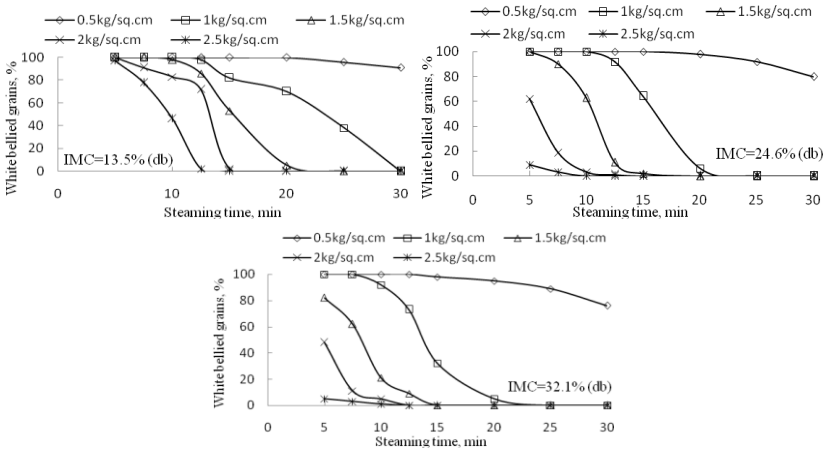


Figure 3. Effect of steaming at different pressures on white bellies (IMC: initial moisture content)

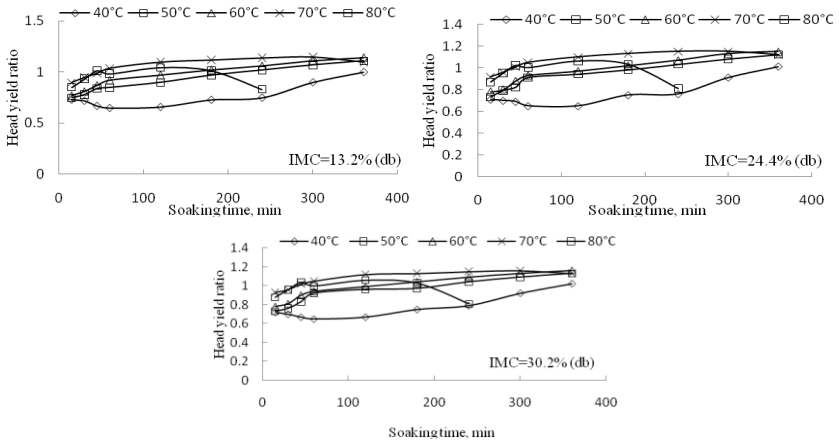
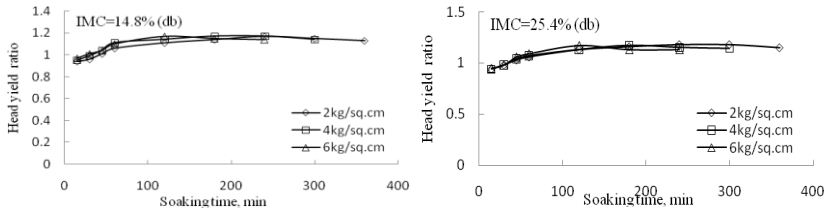


Figure 4. Head yield ratio of rice as affected by soaking temperature



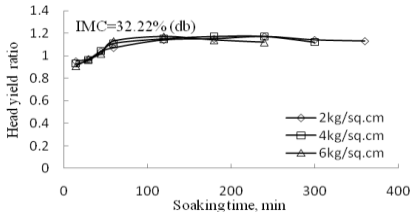
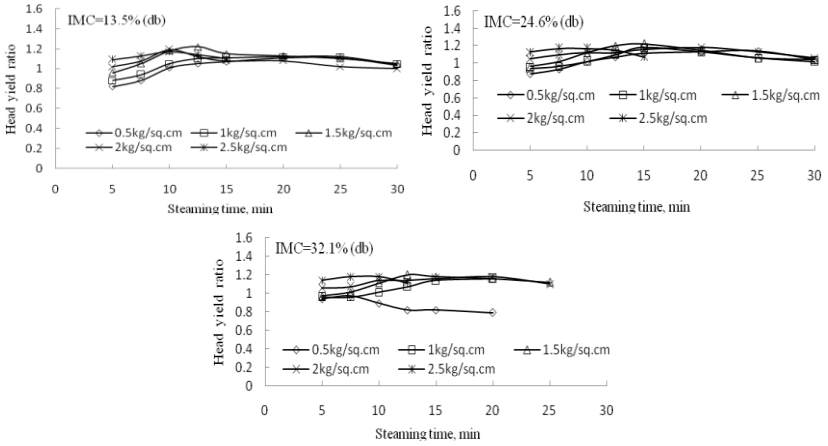


Figure 5. Effect on head rice yield by hydrostatic pressure soaking



Fiure 6. Effect on head rice yield by steaming at different pressures (IMC = initial moisture content)

The head rice yield increased with increase in steaming pressure, initial moisture content, and the duration of steaming (Fig. 6). The maximum head rice yield was obtained under the conditions of a steam pressure of 1.5 $kg \cdot cm^{-2}$ for 12.5-15 min. However, it was observed that the maximum head rice yield was obtained under the conditions of a steam pressure of 1.5 $kg \cdot cm^{-2}$ for 30 min or 2.0 $kg \cdot cm^{-2}$ for 20 min, respectively [6]. The initial grain moisture content did not remarkably affect the head yield though the time of the treatment varied a little with that.

The study suggests that it is possible to achieve complete gelatinization and improve the head rice yield by employing only soaking or steaming under pressure with suitable initial moisture content. The pressure during soaking or steaming is important for the degree of gelatinization.

CONCLUSIONS

The effects of only soaking paddy at different temperatures under atmospheric pressure, soaking at different pressures at a constant temperature (70°C) and steaming under different pressures on the gelatinization of the grain and milling qualities were

studied. It was observed that the steaming operation was quite effective in reducing the white bellies and the extent of reduction was affected by initial moisture content, duration of steaming as well as pressure of steaming. Soaking at 70°C for more than 60 min yielded higher head rice yield as compared to other low temperature soaking treatments. The head rice yield also increased for paddy soaked at 80°C for short duration; however, prolonged soaking at 80°C resulted in more breakage. Soaking under pressure resulted in more head rive yield as compared to soaking at atmospheric pressures. The maximum head rice yield was obtained under the conditions as initial grain moisture content of about 25 g per g dry matter at a steam pressure of 1.5 or 2.0 $kg \cdot cm^{-2}$ for a period of 30 and 20 min, respectively. The study suggests that it is possible to achieve complete gelatinization and improve the head rice yield by employing only soaking or steaming.

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UTICAJ PARAMETARA KVAŠENJA I PARENJA NA KVALITET MLEVENJA PIRINČA (CV. *MTU 1075*)

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Sažetak: Uticaj parametara kvašenja i parenja na kvalitet mlevenja pirinča (Cv. *MTU 1075*) je proučavan pri različitim inicijalnim sadržajima vlage. Kvašenje je

izvođeno pri različitim temperaturama od 40 do 80°C. Tako đe je kvašeno i pri tri apsolutna pritiska od 2.0, 4.0 i 6.0 kg·cm^{-2} pri temperaturi vode za kvašenje od 70°C. Parenje je izvođeno pri apsolutnim pritiscima od 0.5, 1.0, 1.5, 2.0 i 2.5 kg·cm^{-2}. Uočeno je da je povećanje temperature vode za kvašenje kao i pritiska kvašenja pvećalo kvalitet mlevenja pirinča sa većim prinosom i smanjilo gubitke. Parenje na 80°C smanjilo je prinos kada je trajalo više od 120 min. Tokom kvašenja pod pritiskom je postojala razlika u početnom prinosu do oko 10 min kvašenja, a razlika se smanjila kako se vreme kvašenja povećavalo preko toga. Maksimalan prinos bio je postignut obradom sa pritiskom pare od 1.5 kg·cm^{-2} od 12.5 do 15 min. Samo kvašenje pri hidrostatičkom pritisku takođe je povećalo prinos u svim uslovima.

Ključne reči: *kvašenje, parenje, prinos, kvalitet mlevenja, hidrostatički pritisak*

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METERING UNIT PERFORMANCE OF A VACUUM TYPE PRECISION VEGETABLE PLANTER

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Abstract: The objective of this study was to determine the seeding performance of a precision vegetable planter with vacuum type metering unit at different seed spacings and forward speeds using onion and carrot seeds. The seeding performances were investigated and evaluated based on the seed distribution accuracy on sticky belt stand tests in laboratory conditions. The experiments were conducted at the forward speeds of 1.0, 1.5 and 2.0 m s^{-1}, and seed spacing of 25 and 50 mm for each seed. The vacuum plate of precision metering unit with 90 holes and hole diameter of 0.8 mm was used. The seed distribution accuracy was determined according to the factor of variation (V_f) and goodness criteria (λ) which are represented to be compatible with the Poisson distribution. The factors of variation were found in the range of 0.74-0.89 for carrot and 0.52-0.55 for onion. These values indicated that carrot and onion seeds can be planted in the character of precision seeding by a vacuum type vegetable planter. According to results of the experimental tests it was found that seed distribution accuracy of machine was in very good quality for carrot (λ = %78.42-%93.16) and onion (λ = %88.95-%94.11) seeds.

Key words: *carrot, onion, vacuum precision seeding, seed distribution accuracy*

INTRODUCTION

Precision seeding is the preferred method at present and the use of pneumatic precision planters has an increasing trend in the world since it provides more uniform single seed spacing without multiples and misses for row crops and vegetables. It is

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necessary to operate the planters at high performance for sowing of very small vegetable and oil seeds. Because in vegetable planting, seeding rate is very low and providing similar living space without eliminating competition among plants is difficult and seed costs are very high. there are limited number of studies on vegetable precision seeding in the literature even though many studies focused on precision seeding of row crops such as cotton, maize, sunflower, soybean etc.

One of the limited studies was conducted by [1] using belt type and vacuum type vegetable planters and they determined that a belt planter was as effective at singulating spherical seeds (cabbage) and nearly spherical seeds (onion) as the most precise vacuum planter, but seeding uniformity of all planters with elongated (carrot and cucumber) or angular (spinach) seeds was inadequate for precision seeding. The belt planter was also more effective than the vacuum planters at spacing the seeds uniformly within the target area when outliers (missed and multiple seed drops) were removed.

A low-cost pneumatic precision planter was developed and tested in the field by [2]. The evaluation of the precision planter based on the optimized design, and operational parameters revealed that quality of feed index more than 90% with a miss index of about 3-5% can be achieved. Plant spacing accuracy was affected by planter speed; higher planting speeds (>3.8 km h^{-1}) resulted in less accuracy than the slower speeds.

It was investigated by [3] that seed flow rate, seed flow evenness and in-row seed distribution uniformity of fluted rollers were examined in the laboratory experiments for the random seeding of uncoated onion, carrot, canola and coated canola seeds. They developed regression models that include the seed flow rate changes with “large scale fluted roller's active flute length, rates of revolution. They found that seeding unit was capable of sowing of uncoated onion and carrot seeds at “moderate” quality, and coated and uncoated canola seeds at “good” quality” from the point of λ goodness criteria and V_f factor of variation. In this study the seeding performance of the metering unit of a vacuum type precision vegetable planter was determined in carrot and onion seeding at different forward speeds and seed spacings. The seed spacings used in the experiments were chosen specially at very low distances for precision seeding and the response of metering unit was determined under this condition.

MATERIAL AND METHODS

The precision vegetable planter (Fig 1a) used in the experiments was a vacuum type metering unit (Fig 1b) consisting of a vertically operating plate where the pressure differential is supplied by creating vacuum on the side of the disc opposite the seeds. The vacuum plate with 90 holes, hole diameter of 0.8 mm was used. Besides positive pressure is applied to the disc for the hole cleaning after seeds are released. In the experiments, vacuum pressure of 4.0 kPa for carrot, 5.0 kPa for onion was applied while the positive pressure was set to 0.8 kPa was for hole cleaning. A ground-driven wheel transfers the motion to the seed plate with a combination of gears available that provides different seed spacings.

A greased belt stand was used for the tests and the vegetable planter was set to the theoretical seed spacing (Z) of 25 mm and 50 mm for both onion and carrot seeds. The physical properties of the seeds are tabulated in Tab. 1. The carrot seeds were calibrated before experiments using a sieve in the diameter of 1.5 mm.

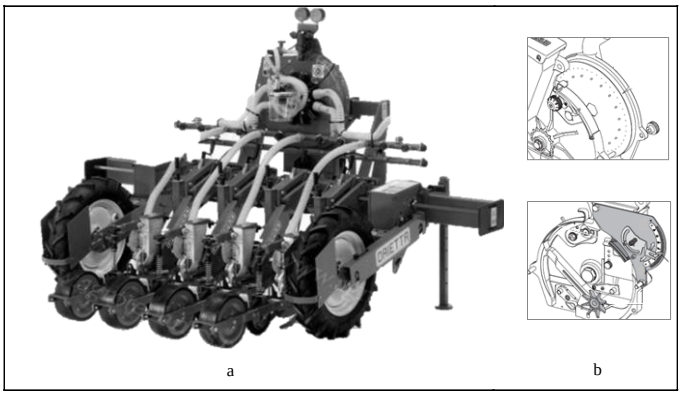

Figure 1. The precision vegetable planter (a) and vacuum type metering unit (b)

Table 1. The physical properties of carrot and onion seeds

Phsical property	*Carrot*		*Onion*	
	Mean	*Standard Error*	*Mean*	*Standard Error*
Length l, mm	*2.28*	*0.103*	*2.93*	*0.069*
Width w, mm	*1.28*	*0.055*	*2.06*	*0.035*
Thickness t, mm	*0.65*	*0.023*	*1.41*	*0.050*
Sphericity ,%	*0.544*	-	*0.697*	-
Thousand seed mass, g	*1.2*	*0.006*	*4.1*	*0.002*

The seed distribution accuracy was determined by conducting sticky belt stand tests in the controlled laboratory conditions from 300 seed bands at each forward speed and seed spacing for each seed. The seeding uniformity performance of the precision vegetable planter was evaluated based on the factor of variation (V_f) and goodness criteria (λ) which are represented to be compatible with the Poisson distribution. The V_f and λ values of seed distribution were calculated using the equations given below for the number of seeds in the 300 bands [4]. Experiments were conducted at the forward speeds of 1.0, 1.5 and 2.0 ms^{-1}.

$$V_f = \frac{S^2}{\mu} \tag{1}$$

$$S^2 = \frac{\sum X_i^2 . f_i - (X_i . f_i)^2 / n}{n-1} \tag{2}$$

Where, X_i ; expected value, f_i ; relative value and n; number of sample. The character of row seed distribution was determined according to V_f values as given in Tab. 2 and the evaluation quality of the in row seed distribution uniformity which depicts the percentage of the bands with 1, 2 and 3 seeds was revealed according to λ values are tabulated in Tab. 3 [5]. The average of the seeds in each band (μ) was assumed to be ≈2 for the evaluation of quality of row seed distribution uniformity.

The experimental data were measured with a computer aided measurement system while the forward speed was controlled by an electronic device.

Table 2. The character of the in row seed distribution as the compatibility to Poisson distribution

V_f	*Evaluation*	*Trend of Seeding*
Vf >1.1	*Negative Binomial Distribution*	*Undesirable seeding type with unacceptable misses and multiples in seed distribution*
0.9 < Vf < 1.1	*Poisson Distribution*	*Character of random seeding*
Vf < 0.9	*Binomial Distribution*	*Character of precision seeding*

Table 3. The quality of the in row seed distribution uniformity

Λ	*Evaluation*
≥ 72	*Very good*
> 65-72	*Good*
> 55-65	*Moderate*
< 55	*Insufficient*

RESULTS AND DISCUSSION

The experiments carried out in the laboratory at the theoretical seed spacing of 25 mm and 50 mm for carrot and onion seeds from 300 seed bands at the forward speeds of 1.0, 1.5, and 2.0 m s^{-1} are given in Tab. 4, Tab. 5, Fig. 2 and Fig. 3.

According to results of the experimental tests, it is clear that in precision carrot seeding at seed spacing of 25 and 50 mm the precision vegetable planter performance was in "very good" quality for each forward speed as the quality of in row seed spacing distribution based on the goodness criteria (Tab. 4). Once the performance of the planter is investigated as the compatibility to Poisson distribution of the seed spacing uniformity, it is seen from Tab. 4 that all V_f values are smaller than 0.9. Namely, the trend of seed distribution is binomial ($V_f < 0.9$). This means that the precision vegetable planter could incorporate carrot seeds into the soil in the character of precision seeding.

Table 4. Seed distribution uniformity results obtained for seeding carrot seeds

Seed spacing (mm)	*Forward speed (m s^{-1})*	μ	λ	*Evaluation of seeding quality*	V_f	*Evaluation of seeding character*
25	*1.0*	*2.12*	*92.63*	*Very good*	*0.79*	*Precision seeding*
	1.5	*1.96*	*84.74*	*Very good*	*0.78*	*Precision seeding*
	2.0	*1.92*	*78.42*	*Very good*	*0.74*	*Precision seeding*
50	*1.0*	*2.10*	*93.16*	*Very good*	*0.79*	*Precision seeding*
	1.5	*2.01*	*87.89*	*Very good*	*0.85*	*Precision seeding*
	2.0	*1.96*	*85.26*	*Very good*	*0.89*	*Precision seeding*

While goodness criteria (λ) value is affected by the increase in forward speed negatively, V_f values are about the same. Negative effect of forward speed occurred at a

seed spacing of 25 mm. Moreover forward speed has negative effects on the relative ratio of seeds number in the band. While the forward speed increases, the relative ratio goes down in the precision carrot seeding at both, 25 mm and 50 mm seed spacing (Fig. 2).

Table 5. Seed distribution uniformity results obtained for seeding onion seeds

Seed spacing (mm)	*Forward speed (m s^{-1})*	*μ*	*λ*	*Evaluation of seeding quality*	*V_f*	*Evaluation of seeding character*
25	*1.0*	*1.96*	*93.68*	*Very good*	*0.52*	*Precision seeding*
	1.5	*1.95*	*91.05*	*Very good*	*0.55*	*Precision seeding*
	2.0	-	-	-	-	-
50	*1.0*	*2.02*	*94.11*	*Very good*	*0.52*	*Precision seeding*
	1.5	*1.98*	*92.05*	*Very good*	*0.55*	*Precision seeding*
	2.0	*1.96*	*88.95*	*Very good*	*0.53*	*Precision seeding*

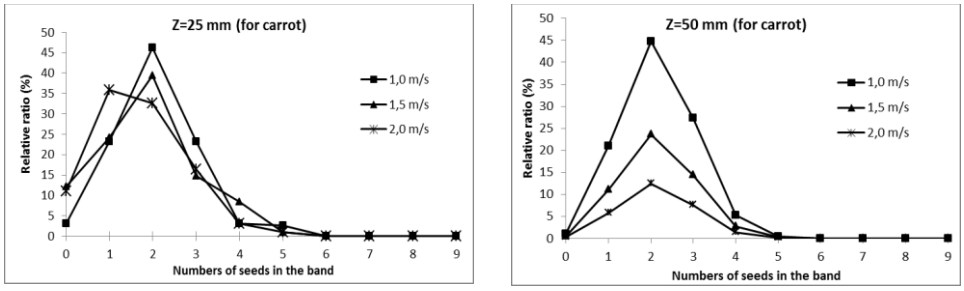

Figure 2. Relative ratio of the bands for carrot seeds

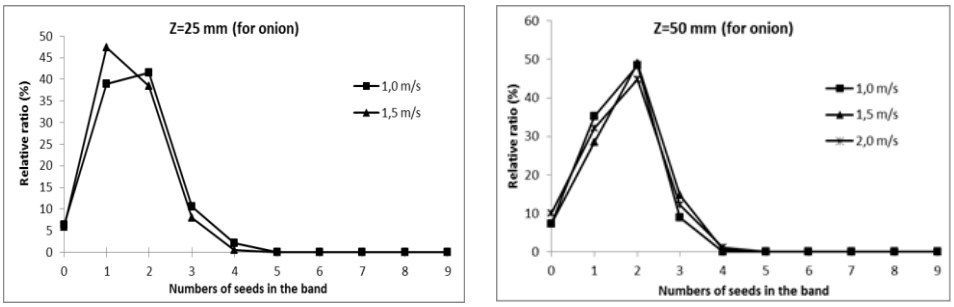

Figure 3. Relative ratio of the bands for onion seeds

As seen from Tab. 5, the onion seeding is in the character of precision seeding and seeding quality is in "very good" quality based on the V_f and λ values respectively, at all forward speeds for the seed spacing of 50 mm. This situation is also valid for the seed spacing of 25 mm, except the forward speed of 2.0 m s^{-1}. As the seed spacing decreases, the seed releasing frequency and the peripheral speed of the seed plate increase. This could be attributed to the fact that catching the seeds on the seed plate hole by vacuum becomes more difficult.

Another reason for the lower performance could be inappropriate use of hole diameter during the experiments. The use of vacuum plate with 1.0 mm hole diameter

instead of 0.8 mm at higher forward speeds may result in increased performance. As seen from the overlapped graphs depicted in figure 3, the relative ratio of seed numbers for onion precision seeding is not affected by the variation of forward speed at all seed spacings and seed spacing contrary to carrot seeding.

For a quality sowing, single seed should be in each band and should not be more three. According to increasing ratio of bands without seed or with more than three seeds, the quality of sowing decreases. In carrot precision seeding the bands include two seeds for seed spacing of 25 mm and 50 mm, generally. But while there are some bands without seeds at all forward speed for 25 mm, but this did not happen for a seed spacing of 50 mm. This means that an increase in seed spacing affects the seed distribution accuracy positively.

Similarly, some bands include four and five seeds for 25 mm, but maximum four seeds in the bands for 50 mm. The numbers of bands with one or three seeds are in similar ratio and they are lower than number of bands with two seeds for both 25 mm and 50 mm. Only, for forward speed of 2.0 m s^{-1}, the number of bands with one seed is more than the others (Tab. 5). Because of this high level forward speed, the quality of seeding is found at the lowest value (λ = 78.42).

In onion precision seeding, the bands include two seeds as similar as carrot seeding, generally. Different from carrot seeding, the numbers of bands with one seed are higher than with three seeds for seed spacing of 25 mm and 50 mm (Fig. 2 and Fig. 3). The number of bands with one seed at forward speed of 1.5 m s^{-1} is higher than at 1.0 m s^{-1} for 25 mm. It can be said that the problem of holding seeds by vacuum on the seed plate started to occur at a forward speed of 1.5 m s^{-1}.

The metering unit of precision vegetable planter can seed onion seeds more precisely than carrot seeds. While V_f values of onion seeding were found within the range of 0.52-0.55. These same values for seeding carrot were found to be between 0.74 and 0.89. The variety of λ values were within the range of λ_{carrot}=78.42-93.16 and λ_{onion}=88.95-94.11 for carrot and onion seeds, respectively.

CONCLUSIONS

The results obtained from experiments indicated that carrot and onion seeds can be planted in the character of precision seeding by the same vacuum type vegetable planter in the “very good” quality. Onion seeding can be achieved more precisely than carrot seeding, but at higher forward speed affects the number of seed in the band at the low seed spacing.

Forward speed is an important variable for the relative ratio of the seed in the bands for carrot especially. The numbers of bands with one or three seeds are in similar ratio for carrot seeding, the numbers of bands with one seed are higher than with three seeds for onion seeding.

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PERFORMANSE MERNE JEDINICE VAKUUMSKE SADILICE ZA PRECIZNU SADNJU POVRĆA

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Sažetak: Cil ovog ispitivanja bio je da odredi performanse rada sadilice za preciznu sadnju povrća sa vakuumskim mernim uređajem pri različitim rastojanjima sadnje i brzinama pri sadnji semena luka i šargarepe. Radne performance su bile ispitivane i ocenjene na osnovu tačnosti distribucije semena na testovima sa lepljivim kaišem u laboratorijskim uslovima. Ogledi su izvođeni pri brzinama od 1.0, 1.5 i 2.0 m s^{-1}, i rastojanjima sadnje od 25 i 50 mm. Korišćena je vakuumska ploča preciznog mernog uređaja sa 90 otvora i prečnikom otvora od 0.8 mm. Tačnost distribucije semena bila je određena prema koeficijentu varijacije (V_f) i kriterijumu uklapanja (λ) koji su predstavljeni kao kompatibilni sa Poisson rasporedom. Koeficijenti varijacije bili su u opsegu od 0.74 do 0.89 za šargarepu i 0.52 do 0.55 za luk. Ove vrednosti pokazuju da semena šargarepe i luka mogu precizno da se seju vakuumskim tipom sadilice za povrće. Prema rezultatima testova tačnost distribucije semena bila je veoma dobra i za semena šargarepe (λ=%78.42-%93.16) i za semena luka (λ=%88.95-%94.11).

Ključne reči: *šargarepa, luk, vakuum precizna sadnja, tačnost dustribucije semena*

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BIOMASS POTENTIAL FROM AGRICULTURE - CASE OF SLOVAKIA AND SERBIA – part 1

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Abstract: The natural resources (oil, coal, natural gas) are insufficient to satisfy the needs of the people for electric and heating energy because sources of fossil fuels are limited. Emission of large quantities of carbon-dioxide into the atmosphere, in the course of combustion processes of solid and liquid fuels have been disrupting the environment. The future lies in the renewable energy sources (*RES*) surrounding us.

The rapid rise of crude oil prices in the early 70-ies of 20th Century focused global attention to the need for efficient use and finding new sources of energy. In addition, energy consumption is growing dramatically in developed countries. *EIA* expects that demand for energy will grow by 56% between 2010 and 2040 (U.S. Energy Information Administration, 2016).

In order to overcome the problems caused by the constant rise in the global population, rapid exploitation of many natural resources, increase of pollution and climate change, the World and Europe must radically change their approach to the production, processing, consumption, storage, recycling and disposal of biological wastes. European 2020 strategy indicates bioeconomy as a key element for sustainable and "green" development in the region (European Commission, 2012). Bioeconomy includes sustainable production of renewable biological resources and their conversion into food, biofuels, bioenergy and bioproducts (eg. bioplastics, biopesticides, etc.). It includes agriculture, forestry, fisheries, food and paper production, as well as part of the chemical, biotechnological and energy industries.

Agriculture is a major consumer but also can become energy producer. Bearing in mind the amount of biomass produced, and the possibilities for its utilization, the negligible amount of biomass that is currently used as an energy source. An important

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feature is that biomass combustion is not an increased content of CO_2 in the atmosphere, as the ecological point of view is very important. The necessity of integrated approach to the biomass policy is given special importance. Biomass is preferred to other sources of renewable energy, due to the increase in the alternative sources of income it provides to the farmers, and the development of the regional economic structures. It is expected that throughout Europe a new "energy producing" division of agriculture is about to unfold, which, in close cooperation with the energy producing and service providing sections of the national economy, may greatly contribute to the reduction of the energy shortage, while finding new sources of income.

Usage of biomass, which is mostly the agricultural waste, would reduce demand of the country for import of fuels, would promote environment protection, and the economy would prosper, which would contribute to the sustainable development of society.

At this study the sources of biomass and its potential will be described, as well as energy from agricultural biomass, with special emphasis on the situation and potential of Slovakia and Serbia in biomass. The possibilities of the use of alternative renewable energy sources were considered, such as biodiesel, biogas and bioethanol. Also the opportunities for development and implementation of the second, third and fourth generation biofuels are listed. The study included both positive and negative impacts of the production and use of renewable energy from agricultural biomass (biofuels) compared to the fossil fuels.

***Key words**: agriculture, biomass, potential, renewable energy*

CURRENT EU POLICY FRAMEWORK

The use of renewable energies (wind power, solar and photovoltaic energy, biomass and biofuels, geothermal energy and heat-pump systems) undeniably contributes to limiting climate change. Furthermore, it plays a part in securing energy supply and creating employment in Europe, thanks to the increase in the production and consumption of local energy. Renewable energies, however, remain on the fringe of the European energy mix as they still cost more than traditional energy sources.

To increase the use of renewable energy sources, in its Renewable Energies Roadmap the EU has set itself the objective of increasing the proportion of renewable energies in its energy mix by 20 % by 2020 (European Renewable Energy Council). To achieve this, EU countries have committed to reaching their own national renewables targets ranging from 10% in Malta to 49% in Sweden. They are also each required to have at least 10% of their transport fuels come from renewable sources by 2020.

All EU countries have adopted national renewable energy action plans showing what actions they intend to take to meet their renewable targets. These plans include sectorial targets for electricity, heating and cooling, and transport; planned policy measures; the different mix of renewable technologies they expect to employ; and the planned use of cooperation mechanisms (European Commission, Renewable energy moving towards a low carbon economy, 2016).

This objective requires progress to be made in the three main sectors where renewable energies are used:

- EU based target for *GHG* emission reductions of 20% relative to emissions in

1990;
- 20% share for renewable energy sources in the energy consumed in the EU with specific target for the Member States;
- 20% savings in energy consumption compared to projections. In addition, there are specific 2020 targets for renewable energy for the transport sector (10%) and decarbonisation of transport fuels (6%). (European Commission, 2014).

In 2014, negotiations about EU energy and climate targets until 2030 EU countries have agreed on a new 2030 Framework for climate and energy, including EU-wide targets and policy objectives for the period between 2020 and 2030. EU countries have already agreed on a renewable energy following targets (European Commission, Climate Action, 2014):
- 40% cut in greenhouse gas emissions compared to 1990 levels;
- at least a 27% share of renewable energy consumption;
- at least 27% energy savings compared with the business-as-usual scenario.

THE ENERGY SAVINGS TARGET AND IMPLEMENTING MEASURES

The 2020 target of saving 20% of the EU's primary energy consumption (compared to projections made in 2007) is not legally binding for Member States, but significant progress has nevertheless been made. After years of growth, primary energy consumption peaked in 2005/2006 (around 1825 Mtoe) and has been slightly decreasing since 2007 (to reach 1730 Mtoe in 2011). This trend is partly due to the economic crisis and partly due to the effectiveness of existing policies. It is also due to reduced energy intensity of EU industry which was 149 toe per million euro in 2010, down from 174 in 2000 and 167 in 2005.

With the adoption of the Energy Efficiency Directive (*EED*) in 2012 there is now a comprehensive legislative framework at *EU* level. This needs to be fully implemented by Member States. The *EED* will help to drive progress in this area, although the Commission's preliminary analysis suggests that with current policies the 2020 target will not be met. The lack of appropriate tools for monitoring progress and measuring impacts on the Member State level is part of the problem. Another major challenge is to mobilize the funds needed to ensure continued progress.

Since 2009-2010, implementing measures have been adopted under the Ecodesign and Energy Labeling Directives on energy related products. These measures reduce the energy demand of industrial and household products leading to savings for end-users. Measures have been adopted for a number of electronic appliances, including domestic dishwashers, refrigerators, washing machines, televisions and tyres as well as industrial products such as motors, fans and pumps. The estimated impact of the adopted ecodesign and labelling measures are energy savings in the range of 90 Mtoe in 2020.

To address the energy consumed in the building stock, in particular for heating and cooling purposes, the EU adopted a revised Energy Performance of Buildings Directive (*EPBD*) in 2010. Besides the obligation for Member States to apply minimum energy performance requirements for new and existing buildings, the Directive requires them to ensure that by 2021 all new buildings are "nearly zero-energy buildings." However, delays and incomplete national measures to implement this directive risk undermining the necessary contribution of the buildings sector towards lower GHG emissions and

reduced energy consumption. The cost-effective savings potential in the building sector is estimated to be 65 Mtoe by 2020. The EU has supported the development of energy efficient technologies, including through public partnerships on energy efficient buildings, green cars and sustainable manufacturing.

In the transport sector, the Regulations establishing performance standards for light duty vehicles have led to substantial reductions in GHG emissions reflected in the fleet average CO_2 emission of new cars from 172 g per kilometer in 2000 to 135,7 g per kilometer in 2011.

LEGISLATION AND POLICY RENEWABLE ENERGY

Renewable sources of energy - wind power, solar power (thermal and photovoltaic), hydro-electric power, tidal power, geothermal energy and biomass/biogas - are an essential alternative to fossil fuels. Using these sources helps not only to reduce greenhouse gas emissions from energy generation and consumption but also to reduce the European Union's (*EU*) dependence on imports of fossil fuels (in particular oil and gas).

In order to reach the ambitious target of a 20% share of energy from renewable sources in the overall energy mix, the EU plans to focus efforts on the electricity, heating and cooling sectors and on biofuels. In transport, which is almost exclusively dependent on oil, the Commission hopes that the share of biofuels in overall fuel consumption will be 10% by 2020.

Policy orientations:

- Promotion of the use of energy from renewable sources (*EC*, Legislation, 2016)
- Renewable Energy Road Map (*EC*, Energy, 2016)
- Intelligent Energy for Europe programme (2003-2006) (*EC*, Energy, 2016)
- The Global Energy Efficiency and Renewable Energy Fund (*EC*, Energy, 2016)

Electricity:

- Renewable energy: the share of renewable energy in the *EU* in 2004 Electricity (*EC*, Energy, 2016)
- Renewable energy: the promotion of electricity from renewable energy sources (*EC*, Energy, 2016)
- Support for electricity from renewable energy sources (*EC*, Energy, 2016)

Heating and cooling:

- Biomass Action Plan (*EC*, Energy, 2016)

Biofuels:

- EU strategy for biofuels (*EC*, Energy, 2016)
- Motor vehicles: use of biofuels (*EC*, Energy, 2016)

Wind energy:

- Promotion of offshore wind energy (*EC*, Energy, 2016)

LEGISLATION/STRATEGY/POLICY IN SLOVAKIA AND SERBIA

European legislation in the energy sector is mainly represented by directive of European Parliament and Council No. 2003/54/*ES* concerning common rules for the

internal electricity market, the directive of European Parliament and Council No. 2003/55/EC concerning common rules for the internal market with natural gas.

The directives were into the law and order of the Slovak Republic fully transposed by Act No. 656/2004 concerning energetic and Act no. 107/2007 concerning the regulation in network industries. Based on this new energy legislation has been issued the Decree of the Ministry of Economy, Regulatory Office for Network Industries and Government Regulation No. 123/2005 were established governing the operation of gas and No. 317/2007 that were established governing the operation of the electricity market.

The RES legislation was developed as a response to the EU Renewable Energy Directive. It is a strategy that outlines how the Slovak republic can reach its 2020 target which is 14 % of energy from renewables by 2020. A major role will play a biomass heat production and promotion of the combined biomass heat and power production. Draft of the Energy Policy was approved by SR Government Resolution no. 29/2006 of 11.01.2006 (Enviroportal, 2016).

Proposal for the Slovakia Energy Security Strategy was approved by SR Government Resolution no. *732/2008 of 15.10.2008 (MH, 2016)*. The aim of Energy Security Strategy is to achieve competitive power, ensuring safe, reliable and efficient delivery of all forms of energy at affordable prices, taking into account customer, environmental protection, sustainable development, security of supply and technical safety.

Strategic and program documents in the area of using *RES*:

- 2006 Energy policy of Slovakia,
- 2007 The strategy of higher utilization of *RES*,
- 2008 Energy Security Strategy,
- 2009 *Act No 309/2009* Coll. the promotion of *RES* and highly efficient *CHP* 2009,
- Directive *2009/28/EC* on the promotion of *RES*.

From the total arable land area in Serbia of 4 867 000 ha, 40% can be utilized as a source of biomass, as well as 16% of agricultural land under fruits and vegetables can be utilized for this purpose.

The actual annual production of biomass in Serbia is around 12,5 million tons. Of this amount, 1,7 million tons of agricultural biomass, and 1,02 million tons comes from forestry.

ENERGY FROM BIOMASS AND BIOGAS - DEFINITION AND BASIC TERMS

"Biomass shall mean the biodegradable fraction of products, waste and residues from agriculture (including vegetal and animal substances), forestry and related industries, as well as the biodegradable fraction of industrial and municipal waste" (Definition according to the Directive 2001/77/*EC* of the European Parliament and of the Council of 27 September 2001 on the promotion of electricity produced from renewable energy sources in the internal electricity market).

Biomass is a plant material, which is used directly as a fuel, or is converted to other forms before the combustion.

The use of biomass as an energy source dates back to ancient times, so that in many developing countries of the world and remains a primary fuel in households.

Given that in recent years starts organized use of biomass outside the household, and that counts as a significant energy source, biomass is treated as a new renewable energy source. Energy potential of biomass is in the first place among the other renewable energy sources.

The potential for bioenergy is very large and very prevalent around the world. Today, biomass is already the main source of the world's energy needs from all available renewable energy sources, reaching 12% (50 *EJ*/yr.) of the total global needs (406 *EJ*/yr.) The use of biomass is mainly based on agricultural and forestry wastes.

BIOMASS FROM AGRICULTURE

Agricultural biomass consists of the remains of various crops: straw, corn stalks, cobs, stalks, husks, seeds. This type of biomass has a low power of firewood and a large proportion of moisture and various impurities.

Agricultural biomass can have multi-purpose use, such as producing of:

- humus (plowed),
- fodder (treated with chemicals, mixing with proteins, etc.),
- heat (combustion),
- building materials (various pressed plates),
- parts of furniture (chipboard),
- alcohol (fermentation),
- biogas (anaerobic fermentation),
- paper and packaging,
- cleaning chemicals, decorative items,
- as well as for many other purposes.

Given that use of agricultural biomass often causes problems in practice, compromise was found in use of: ¼ biomass plowed in order to improve soil fertility, ¼ used for the production of animal feed, ¼ for energy production and ¼ for other purposes (alcohol industry, furniture, packaging, paper, etc.). The production of energy from agricultural biomass would provide significant savings if this energy is used for heating in winter or for drying agricultural crops.

According to the physical state of matter, as well as influence on energy source use, biomass can be: solid, liquid and gas.

Solid biomass are the remains from crop production, the remains of orchards and wine yards pruning, forestry residues, plant mass of fast growers (known as Short Rotation Coppice - *SRC*), and above all fast growing forests, part of selected municipal waste, residues from the wood processing industry, remains of primary and secondary processing of agricultural products and more.

Liquid biomass is the liquid biofuels – plant oils, transesterificated plant oils – biodiesel and bioethanol.

Gaseous biomass represents biogas, which can be produced from animal manure and energy crops (grass and maize silage), or as a raw material may be used and other waste materials. Gaseous, even liquid, biomass, are the products of gasification and pyrolysis of solid biomass.

Given the existence of a very large number of waste materials, which to some extent includes biomass, but in addition to biomass contains harmful and dangerous substances,

developed countries under the term biomass mainly define fuel that can be regarded as a clean fuel, with no harmful and dangerous substances.

Table 1. Description of the materials that are and are not included under the term „biomass", concerning use as renewable energy source

Biomass as renewable fuel does include:	*Biomass as renewable fuel does not include:*
Plants and plant parts	*Fossil fuels*
Fuel produced from plants and plant parts, which all components and mid-products are produced from biomass, also.	*Peat*
Residues and by-products of plant and animal origin in agriculture, forestry and commercial fish production	*Mixture of municipal waste*
Organic waste, such as: Biodegradable waste from processes in food industry, biodegradable residues from the kitchen, separated biological waste from households and firms, biodegradable waste from the wood industry and waste to maintain the natural environment. It is necessary that this type of waste has a calorific value of at least 11 000 kJ·kg^{-1} (criterion of the environmental protection).	*Wood Residues containing polychlorinated biphenyls or polychlorinated terphenyls, mercury and other harmful substances that are emitted in above limits quantities during the thermal use of wood.*
Gas produced from biomass by gasification or pyrolysis and other products, as a result of these processes.	*Paper and cardboard*
	Sewage
Alcohol (as fuel) produced from biomass whose components and intermediate products are produced from the biomass, also.	*Textile*
	Animal body parts
Biogas is produced by anaerobic fermentation, which doesn't include fermentation of materials that do not fall into biomass and in which there is no more than 10% of sewage	*Gas from sewage treatment*
Waste wood from wood processing industry and processing of wood materials	*Gas from landfills*

The biomass as a renewable energy source usually involves materials made of plant material, including products, by-products, waste and residues, and plant mass, but without the harmful and hazardous substances, which can be found in painted and otherwise chemically treated wood, in the processes in the wood processing industry.

Precise definition of the meaning of biomass as a renewable energy source from German document Biomass Ordinance on Generation of Electricity from Biomass (Biomass Ordinance - Biomass V), from June 2001, is given in Tab. 1.

Biomass is part of a closed carbon cycle. Carbon from the atmosphere is stored in plants and combustion releases carbon back to the atmosphere as carbon dioxide (CO_2). As long as the principle of renewable development is followed (planting same amount of trees as cut), this form of energy has no significant impact on the environment.

When biomass is used as fuel instead of fossil fuel emits the same amount of CO_2 into the atmosphere. Carbon content in biomass, with approximately 50% of its total mass, is already part of the atmospheric carbon cycle. When fossil fuels it's different, because their combustion releases in the atmosphere additional carbon amount that was trapped in the long-term carbon reservoirs.

CHEMICAL CONTENT OF BIOMASS

Biomass consists mainly of carbon, hydrogen and oxygen. In addition, significant amounts of trace elements may be found in different types of biomass, such as straw contains very large amounts of chlorine and/or silicon, and rapeseed relatively high amounts of nitrogen. The presence of these trace elements may cause some problems when using, for example, during the combustion of chlorine can cause corrosion in the boiler, silicon can buildup of deposits, nitrogen will increase the nitrogen oxide emissions.

The energy content of certain types of biomass is usually expressed through the Low Level Heat (*LHV*). *LHV* depends on the moisture content in the biomass, and the content of hydrogen in the fuel. Actual biomass *LHV* with known moisture content can be calculated from *LHV* values of dry biomass with the following equation:

$$H_u(w) = H_u(wf)(100 - w) - \frac{2{,}44w}{100} \quad (1)$$

where:

Hu(w)	[MJ·kg^{-1}]	- *LHV* for determined moisture content in biomass,
Hu(wf)	[MJ·kg^{-1}]	- *LHV* of totally dry biomass,
w	[%]	- moisture content,
2,44	[-]	- water evaporation *const.*

ENERGY FROM BIOMASS

Biomass energy can be obtained in several ways:

- direct burning to obtain heat (wood, crop residues, waste wood)
- digestion - the processing of animal waste (manure) into biogas,
- processing of biomass into alcohol (ethanol) or the production of vegetable oil

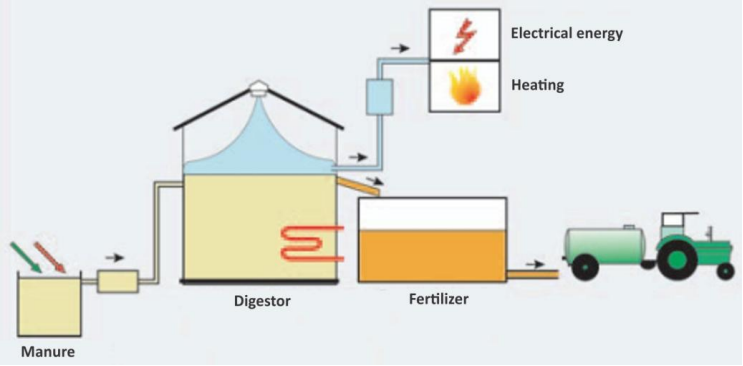

Figure 1. Process of manure treatment and production of organic fertilizer and biogas

In agriculture, there are large amounts of crop residues which can be partly used for energy purposes. It is not recommended to completely remove all plant residues from the

ground, so as not to become poor soil and disturb the natural cycle of the circulation of matter in it. Often, due to ignorance about processing the plant residues, farmers burn the fields, which is very harmful.

Biomass from livestock production (livestock manure) is also an excellent energy source. The energy generated from the liquid manure in the exploitation does not emit harmful gases that are produced from combustion of conventional fossil fuels and thus contributing to greater environmental protection. For example, about 10 to 12 kg of liquid manure with 4 to 10% dry matter is needed to obtain 1 m^3 of biogas. Domestic animals whose liquid manure can be economically used for the production of biogas are: dairy cows, cattle, fattening pigs, laying hens.

The most important problem is actually investing in systems for the production of biogas. If the energy invested in the exploitation and processing of an energy source is higher than the energy yield of this resource, the exploitation is total loss. The aim is to create a self-sustainable system. Installations for the production of energy from biomass in the future will enable progress in the development of ecology, agriculture, energy and the whole economy of each region that opt for their use and operation.

BIOFUELS FROM BIOMASS

The world is focused on the development of new processes for the production of biofuels from biomass. Stock of oil sources are globally estimated at 50 years and now is seriously considered the use of biomass, especially in terms of obtaining biofuels. An increasing number of countries in the world is gradually increasing percentage of biofuel mixed with fossil fuels and thus form a new policy of supply.

Biofuels are liquid or gaseous fuels, produced from biomass. Biofuels can be produced directly from plants or indirectly from industrial, commercial, domestic and agricultural waste.

There are three basic methods of biofuel production:

1. The first is based on the burning of dry organic waste (household waste, industrial and agricultural waste, straw, wood and peat).
2. Then there is the fermentation of wet waste (animal manure) without the presence of oxygen to produce biofuel with 60% methane and the fermentation of sugar cane or corn to produce alcohol and ester.
3. Third is energy obtained from forestry, farming or fast growing trees for fuel production.

However, the best known certainly is fermentation, whose products are the two most well-known types of alcohols and esters. They would theoretically be able to replace fossil fuels, but given that it was necessary to adapt the plant, commonly used in a mixture with fossil fuels.

Biofuels have the potential aimed at reducing the production of carbon dioxide, which is primarily based on the fact that the plants from which produce biofuels absorb CO_2 during their growth, which is released during the combustion of biofuels. However, since the energy is required for the growth and cultivation of plants, their conversion into biofuels and later distribution, additionally release carbon dioxide. Emissions of carbon dioxide that is released during the production and distribution of biofuels can be calculated using a technique called "Life Cycle Analysis (*LCA*)", which is based on the

monitoring and calculation of CO_2 emissions from the beginning of plant growth, or putting seeds in the ground, to release gas during engine combustion. Various studies have been made for different biofuels, whose results were also different. Most of the *LCA* studies showed how biofuels compared to fossil fuels create significantly less harmful greenhouse gases and their use, i.e. the replacement of fossil fuels would mean significant decrease of greenhouse gases. In addition to reduced CO_2 emissions and the emissions of Sulphur oxides, particulate matter and carbon monoxide emissions are reduced, as well.

There are different types of biofuels, which are divided into first and second generation, depending on the source material for production, costs of production, prices and CO_2 emissions.

The first generation of biofuels is based on the production of sugar, starch, vegetable oils or animal fats, while second generation production uses agricultural and forest waste. The raw materials used in the production of biofuels used for food production, thereby increasing prices of raw materials, and with them the cost of production. Therefore, in collaboration with researchers made the second generation of biofuels. The development of second generation biofuels is still in its early stages.

Currently, the market is dominated by: biofuels, biodiesel and bioethanol.

BIOGAS

When it comes to biogas, it usually refers to gas with a large amount of methane, produced by fermentation of organic substances like manure, sludge from waste water treatment, municipal solid waste or any other biodegradable materials in anaerobic conditions. It is often used for biogas and names such as marsh gas, landfill gas, swamp gas and the like, according to the source. Each variant has different levels of methane and carbon dioxide in it, along with a smaller proportion of other gases.

This process is becoming increasingly popular for the treatment of organic waste, because it provides a convenient way of turning waste into electricity, thereby reducing the amount of waste and the number of pathogenic substances contained in waste. Also, the use of biogas is encouraged, because in this way obtain the power, while not increasing the amount of carbon dioxide in the atmosphere. Also, the methane is burned much cleaner than coal.

Table 2. Energy obtained from gas combustion

Gas	*Obtained energy ($kWh \cdot m^{-3}$)*
Biogas	*7*
Natural gas	*10*
Propane	*26*
Methane	*10*
Hydrogen	*3*

Anaerobic bacteria break down the organic matter in the absence of oxygen and produce biogas as a product of the decomposition. The most commonly used organic matter to produce biogas is cattle manure. The primary advantages of biogas production

from manure are: nutrient recycling, obtaining high-quality fertilizer for further use in agriculture and avoiding odour of manure. In addition to these primary benefits resulting biogas is a very useful product. Biogas consists of about 70% of methane (CH_4), and the rest consisting of carbon dioxide, carbon monoxide and nitrogen. The relative ratio of gases depending on treated material and treatment process.

Biogas has a significant energy value of about 7 $kWh \cdot m^{-3}$ which makes it very cost effective and universal fuel, far more cost effective than other fossil fuels and biomass.

BIODIESEL

Biodiesel is an environmental friendly energy source, which is obtained from vegetable oils with multiple benefits and advantages compared to conventional types of fuel. Their uses reduce the emission of gases and avoid creating the "greenhouse effect". The combustion of biodiesel produced carbon dioxide, which is neutral. Biodiesel does not contain a sulfur, lead or nitrogen compounds. Better is burned in the engine, and its use reduces pollution of air, water and human environment even three times, because it is biodegradable. The by-products formed during biodiesel production (glycerin, fatty acids, lecithin) can also be used, reducing the need for their imports. Glycerin is a true ecological engine coolant, and has many uses in the pharmaceutical and cosmetic industries.

Unlike the conventional fuel, biodiesel does not contain sulfur (i.e. sulfur content is very low), thereby reducing the potential for acid rain. Biodiesel contains no toxic aromatic compounds such as benzene. The high oxygen content contributes to reducing the content of unburned particulate matter (or soot) in the exhaust gas, while contributing to more complete combustion and reduced emissions of carbon monoxide. As with all fuels, burning biodiesel produces carbon dioxide, however, since plants use carbon dioxide from the atmosphere (photosynthesis) for its growth, carbon dioxide formed by combustion of the fuel balances with carbon dioxide absorbed during the growth of annual plants used as raw materials for the preparation of vegetable oils. Although the expression "diesel" enters his name, biodiesel doesn't contain no petroleum products or other fossil fuels. In bio-diesel are non-toxic, biodegradable and renewable raw materials

Production and use of biodiesel

Biodiesel is defined by European standard *EN* 14214 from 2003. In Serbia, is defined in 2006 by the state standard *SRPS* (*JUS*) *EN* 14214 "Automotive fuels". Fatty acid methyl esters for diesel engines, requirements and test methods "(which is identical to the European standard *EN* 14214). In addition, in May 2006 is adopted the "Regulation on technical and other requirements for liquid fuels" which defines technical and other requirements that fuels must fulfill.

In the *EU* one hectare of oilseed rape provides a sufficient amount of grain for the production of 1.090 liters of biodiesel fuel. However, in Vojvodina province, rapeseed, sunflower and soybean, achieve significantly lower yields than the European averages. With an average yield of 1,69 $t \cdot ha^{-1}$, and seed oil content of 36%, 1 ha of oilseed rape in Serbia provides 608 kg of oil, or about 690 liters of biodiesel. Average yield of sunflower in Serbia is 1,79 $t \cdot ha^{-1}$, and with the oil content of 40% can be produced 16 $kg \cdot ha^{-1}$ or 816 $l \cdot ha^{-1}$ of biodiesel from that sunflower. The average soybean yield in

Serbia is 2,25 $t \cdot ha^{-1}$, while the oil content in grain of 18% can give biodiesel yield of 405 $kg \cdot ha^{-1}$ or 460 $l \cdot ha^{-1}$.

Serbia has significant potential of land for production of raw materials for processing into biodiesel, which is estimated at about 10% of the total arable land. With this area it is possible to provide sufficient amount of raw materials for production of 210 to 250 thousand tons of biodiesel per year, which is enough to replace 13-16% of fossil diesel in Serbia. Currently, rapeseed appears as the only feedstock for biodiesel production. Unprofitable production, inexperience and inadequate agricultural practices are the main obstacles to increased production of rapeseed. The most important reserve for the provision of large quantities of raw materials for biodiesel is increasing the yield of oilseeds, mainly rapeseed. They are well below the European average. For several reasons, sunflower is imposed as more favorable raw material for biodiesel production in Serbia.

The competitiveness of biodiesel is determined primarily by two factors: the retail price of Euro-diesel fuel and the price of biodiesel, which largely depends on the price of feedstock, and prices of oilseeds. Analysis showed that the price of biodiesel based on sunflower and rapeseed is higher than the cost of Euro-diesel fuel, even assuming a relatively modest purchase price of these oilseeds grains.

In Serbia a decade ago were founded several companies that were involved in the manufacture of biodiesel. However, due to the high excise duties, these enterprises are extinguished or its business refocused on the production of edible oils. With the same reason in Serbia cannot be found either biodiesel imports.

BIOETHANOL

Bioethanol can be obtained by fermentation of simple sugars from various types of biomass.

Most often are used different carbohydrate raw materials of the general formula $(CH_2O)n$. Raw materials can be divided into three groups: sugar (sugar beets, sugar cane, sorghum, fruit, etc.), starch (corn, wheat, rice, potato, cassava, sweet potato, barley, etc.) and lignocellulosic (wood, agricultural surpluses, municipal waste, etc.). Lignocellulosic and starch materials are required to undergo a corresponding pre-treatment to make them suitable for the decomposition, while the sugar feedstock directly degrade the action of microorganisms. On the other hand, the use of sugar and starch raw materials affects the economy of the country and the availability of food. Therefore, more attention is paid to the use of second-generation raw materials which include lignocellulosic biomass. In recent years, the production of bioethanol used and algae, chitin and various industrial by-products.

The production of bioethanol from lignocellulosic raw material provides several benefits: lower prices of raw materials, increasing arable land for agricultural crops intended for human and animal nutrition, less use of fossil fuels.

Like alcohol, bioethanol is produced by the alcoholic fermentation of sugar by yeast, followed by a purification process. If the raw material is grains, the starch is converted to sugar by enzymes.

During this process is created a product that can be used as animal feed enriched with protein, with a protein content of 30%.

Bioethanol is used in a mixture with gasoline in various concentrations. In Brazil is even used in the undiluted state (*E100*). In Germany, the standard *DIN EN 228*, allows the use of a mixture of fuel containing up to 5% bioethanol (*E5*). Vehicle engines that are tailored and flexible for different fuels (fuel flexible vehicles - *FFV*) can use fuels containing up to 85% bioethanol (*E85*).

Mixing bioethanol fuel in the EU is allowed up to 5% (regulated by the same standard *EN228*), which requires a limit of water content in order to avoid phase of separation of ethanol and gasoline mixture. The use of bioethanol offers certain advantages that are reflected in lower toxicity and better biodegradability, and its market price does not depend on oil prices. The downside of the use of bioethanol is reflected in the poor sustainability of some sources of biomass, unfavorable energy balance, lack of efficiency of microorganisms, hygroscopic nature of the fluids and higher fuel consumption.

Another possibility is the use of bioethanol for production of ethyl tert-butyl ether (*ETBE*) that contains 74% of bio-ethanol. *ETBE* can be used as a replacement for methyl tert-butyl ether (*MTBE*), which is derived exclusively from non-renewable sources, and as an additive to reduce the knocking in an engine.

Since 2004 is intensified the production of bio-ethanol as a fuel. In 2007, the world production ranged about 40 millions m³ of bioethanol. Brazil is the world's leading producer of bioethanol from sugar cane.

The production costs of biofuels and the requirement for competitiveness affecting the prices of agricultural raw materials. In addition to increasing efficiency in converting raw materials into fuel, introduction of new materials will also generally encourage the use of biofuels.

Placing of by-products of biofuel production on the market is also very important for the final cost-effectiveness of biofuels. For example, glycerin generated during the manufacture of biodiesel can be purified to pharmaceutical quality, and by-products of bioethanol production can be used as animal feed enriched with proteins.

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