DOI : 10.5958/0974-0112.2018.00106.8

Indian J. Hort. 75(4), December 2018: 639-646

Economic viability of drumstick based agri-horticulture system to replace tobacco in Central Gujarat: A modified partial budgeting approach

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ABSTRACT

A partial budgeting approach was used to evaluate drumstick based cropping system against tobacco crop. The study was based on data generated at research farm during 2003-2009. The drumstick based cropping system was not only found to be remunerative than tobacco but also provided environmental services in terms of soil carbon built up and nutrient saving in the soil. This holds promise for agro-ecosystem of central Gujarat, which has predominant tobacco mono cropping system that is averse to soil conservation. Besides saving in irrigation water, the cropping systems enhanced returns over variable cost, saving in soil nutrients valued at Rs 657 ha^{-1} and sustained soil carbon built up valued at Rs 3696 ha^{-1}. This environmental benefits provided by drumstick based production system has implications for resource conservation and environmental security, thus, making it legitimate in view of the national action framework to find alternative crop after signing the Framework Convention on Tobacco Control of World Health Organization.

Key words: *Moringa oelifera*, *nicotiana tobacum*, environmental security, resource conservation, returns over variable cost.

INTRODUCTION

Decision to include agro-forestry/ agri-horticulture in crop programmes world over is necessitated by various dynamic and sustainability factors such as soil health, soil degradation and nutrient loss prevention (Reddy and Suresh, 7). The glory of green revolution is under stress as this has led to several new challenges like decline in factor productivity, degradation of lands and water resources, diminishing biodiversity, depletion of ground water table, increase in environmental pollution and resultant climatic changes (Sharma *et al.*, 8). The second generation problem in Indian agriculture such as lowering of water-table, nutrient imbalance, soil degradation, salinity, environmental pollution and decline in farm profit warrant shifting from mono cropping system to tree based system, which holds lot of promise in alleviating these problems apart from fulfilling other objectives (Gill and Ahlawat, 2). In fact, crop diversification now forms an effective strategy for many of the major ailments of developing country such as India for food security, poverty alleviation, employment generation, sustainable agricultural development and environmental improvement (Hegde *et al.*, 3). However, diversification from existing to alternative production systems necessitates budgeting of sources, both natural and material, before recommending them for the benefit of stakeholders. Farmers, nevertheless, are willing to adopt any new technology if the technology is compatible with their local conditions (De Graaff *et al.*, 1; Wejnert, 12). A simple approach to account for the saving in these resources, which could easily be understood, is, therefore, imperative. The present study uses a modified partial budgeting template to examine these issues and, thus, contributes to the existing body of literature. The present study, specifically, has examined the economic viability of drumstick + green gram - fennel cropping system against the existing tobacco crop grown in the central Gujarat region and has argued for a shift from the existing tobacco crop to the alternative agri-horticulture system in terms of its economic viability and environmental security. The hypotheses of the study was that drumstick based cropping system is an alternative to tobacco crop in view of resource saving, profitability and environmentally sustainability.

The existing cropping system

Tobacco is cultivated in around 65-85 thousand ha in Gujarat, the major type being bidi tobacco. The production of bidi tobacco in Gujarat is largely concentrated in Middle Gujarat Zone comprising Kheda, Anand and Vadodara districts (90% of total production of Gujarat) (http://aau.in/college-menu/208/211). The system of long fallow during intensive period of rainfall and before taking of tobacco is a prominent practice

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in the region. This system contributes to severe soil erosion as splash and excess runoff from bare soil results in loss of soil organic matter and nutrients (Singh, 9). The annual rainfall pattern of the region further suggests delaying tobacco transplantation beyond 218th Julian day (6th day of August) which could put a pressure on soil health (Patel and Dhiman, 6). The health effect of tobacco on human being, however, discriminates against taking this crop. The tobacco epidemic is estimated to kill 8 million people annually, with 80% of deaths in developing countries by 2030 (WHO, 13). Therefore, a shift from tobacco cropping system to another alternative crop/ cropping system is imperative.

The alternative drumstick based cropping system

Drumstick based cropping system has been tested at the research farm of Central Soil & Water Conservation Research & Training Institute, Research Centre, Vasad. While resource conservation could be a significant factor for shifting to resource conserving cropping system considering the water footprint of crops, efforts to study this aspect have been few. In this perspective, water saving in rainfed areas could be a strong reason for crop diversification as crop like tobacco with total water footprint of 2925 m^3t^{-1} does not stand a chance against vegetables with a water footprint of 322 m^3t^{-1} (Mekonnen and Hoekstra, 5).

Drumstick based cropping system

Kharif green gram (*Phaseolus radiatus* L.) CV, K-852, rabi fennel (*Foeniculum vulgare Mill.*) CV, G F-1 and drumstick (*Moringa oelifera* Linn.) CV – Multiplex as agroforestry system has been suggested as an alternative cropping system to tobacco in the region due to its high returns (Singh *et al*., 14). Drumstick is raised on pits of 75cm × 75cm × 75cm size, dug at 4m × 4m spacing, transplanting of seedlings done in the month of July after good soaking rains and saturation of soil profile. Ammonium sulphate, urea, dia ammonium phosphate and muriate of potash is applied annually per tree during mid of July every year, after first year of planting. Drumstick is pruned every year up to the height of 1.75 m in the middle of June and has little shade effect especially on *Kharif* crop of green gram. Fennel (*Foeniculum vulgare Mill.*) cultivar G F-1 is grown as an alley cropping system in between two rows of drumstick. Twenty to twenty-five days old seedlings of fennel are transplanted at row spacing of 70 to 75 cm apart. Nitrogen, P_2O_5 and K_2O are applied as a basal dose and Nitrogen is applied as top dressing in two splits. Four irrigations each of 40 to 45 mm depth are required. Two weedings and soil working are done at 20 and 40 days after sowing/transplanting. Standard package of practices are followed for the crops under irrigated condition.

MATERIALS AND METHODS

The new drumstick + green gram – fennel cropping system provides intangible benefits in terms of soil carbon buildup and resource conservation against the existing tobacco mono cropping system. Similarly, costs (intangible) are involved in on-farm knowledge generation and dissemination of the same in the target domain area. These need to be suitably accounted in assessing potential viability of the new system before its trial and subsequent transfer in the farmers' fields.

Indirect costs and benefits considered in respect of the new cropping system over existing system

S. No.	Indirect costs	Indirect benefits
1	On farm knowledge generation	Soil carbon build up
2	Knowledge dissemination	Soil conservation
3	Management cost and risk premium on capital	

Partial budget template in a slight modified form has been used. It is a simple, transparent, easy to understand. The method uses standard partial budgeting methodology incorporating opportunity costs of inputs and research costs, extension costs, probability of field performance, depreciation of technology and rate of adoption. In this process, the information generated on farm can be used to measure the 'economic viability' of new technologies, by utilizing the data from field experiments generated by agricultural scientists. After economically validating the generated technology at the research station level, the agricultural extension specialist/ agricultural economist / social scientist can obtain the relevant data from the farmers who have adopted the new technology and use this same partial budgeting framework to find the divergence between the economic viability at the research station level and the farm level. The divergence, if any, can be bridged through policy interventions before large scale up scaling of the concerned technology in the field.

The debit side of the partial budget accounted for what is lost due to the adoption of the new technology. This, in addition to added costs on account of seed, fertilizer and pesticide, included costs such as management cost, risk premium, research and extension cost of transferring the technology to the potential area of its adoption. The management cost and risk premium on working capital was considered as 10%. Similarly, interest was taken as 5% for half the period of production. A 50 per cent probability of better performance of the new cropping system

was considered with a low rate of adoption (0.2). The credit side entailed what was gained due to new technology over the existing technology in terms of either saving in resource use or gain in production. Thus, the credit side included, apart from benefits like saving in irrigation, labour, returns from the cropping system, health and environmental benefits as a result of replacing tobacco crop.

The secondary data used in the study was collected from the experimental records of an experiment conducted for six years (2003-04 to 2008-09) at Research farm of Central Soil & Water Conservation Research Institute, Research Centre, Vasad. The yield data on drumstick was corroborated with survey of 32 drumstick growing farmers in Anand district. Crop production data on tobacco and drumstick + green gram – fennel were used to work out the net returns and economic viability of the later system in the region. The input – output data on drumstick, fennel and green gram crops were analyzed based on the prevailing market price of the year 2011-12 to work out the economics of the pure crops and agroforestry systems.

Table 2 Costs (physical and monetary) and returns (₹ ha^{-1}) of the cropping systems.

Item	Drumstick +Green gram –Fennel			Tobacco
	Drumstick	Green gram	Fennel	
Seed/plants (kg/Nos)	833	31.7	19.8	13000
(Rs)	1666	475.5	396	520
Fertilizer (kg)	59.5	140.0	243.0	458
(Rs)	476	1488.1	1845.2	2200
Insecticide (kg)	-	13.4	71.4	-
(Rs)		474.4	1286	
Labour (man days)	71	70	150	175
(Rs)	7100	7000	15000	17500
Irrigation Nos)	-	1	4	8
(Rs)		432	1728	3456
Total cost	9242	8964	17241	23676

* Cost 'A' basis
Output price (₹ kg^{-1}): Tobacco-35, Drumstick-10, Fennel-80, Green gram-20, Fuelwood-0.25, Fodder-0.50

RESULTS AND DISCUSSION

Tobacco yield worked out to be 14.76 q/ha during the period under study. In the new cropping system, green gram and fennel yielded 430 and 596 $kgha^{-1}$, respectively. The average harvest of green drumstick pods over the study period was 1578 $kgha^{-1}$. The new cropping system yield as realized in the field is given in Table 1. The physical and monetary input details of the crops are given in Table 2. Taking local prices of the outputs in the area, the returns over variable costs worked out to be ₹ 38,477/ha and ₹ 28276/ ha in drumstick + green gram – fennel and tobacco, respectively. The tangible benefits definitely make the case for the new cropping system stronger. However, the saving in irrigation water by replacing tobacco with the new cropping system is bonus to the natural eco system of the region.

Drumstick is a rain fed horticultural crop and does not require additional irrigation water for normal growth and development. It thrives well under middle Gujarat region without irrigation. Growing of Drumstick as alternate crop for tobacco in the region may save irrigation water and may be used for growing of other irrigated crops. In this way area under irrigation can be increased. Further, green gram being rain fed cover crop grown in *kharif* season reduces the risk of soil erosion. Fennel crop (100 days) requires four irrigation of 45 mm each, where as tobacco (180 days) requires eight irrigation of 75 mm for maturity. This works out to be ₹ 1130/ha. Thus, growing of drumstick + green gram- fennel saves irrigation water which may be made available for other crops in the region.

It was revealed that against the traditional cropping system of tobacco a soil carbon built up of 0.08% and nutrient saving of 21 kg ha^{-1} P_2O_5 and 27kg ha^{-1} K_2O was observed in drumstick against tobacco (Table 1). Taking the soil bulk density of the region as 1.4 g/cm^3 (soil test parameter at the research farm of CS&WCR&TI, RC, Vasad) and soil depth of 30 cm the soil carbon value gives 42 tC/ha for a 1% change in the soil organic carbon. A 0.08 per cent

Table 1. Yield of crops (kg ha^{-1}), Soil Organic Carbon (%), P_2O_5 and K_2O content under different cropping systems (Period: 2003-04 to 2008-09).

Crop	Green gram	Fennel	Tobacco	Drumstick Yield			Organic Carbon (%)	P_2O_5 (kg/ha)	K_2O (kg/ha)
				Green Pods	Fuel	Green fodder			
Drumstick +Green gram –Fennel	430	596	-	1578	1077	2287	0.49	83	283
Tobacco	-	-	1476	-	-	-	0.41	62	254

built up due to the new cropping system works out to be 3.36 tC/ha. Imputing a value to this at a shadow carbon price of US $20/t C (₹ 55=US $1), this works out to be ₹ 3696/ha. Similarly, the nutrients P_2O_5 and K_2O valued at the nutrient prices of phosphorus and potash supplied through Dia Ammonium Phosphtae and Muriate of Potash works out to be ₹ 657/ha. Thus, the new cropping system not only saved soil nutrients valued but also sustained soil carbon. This environmental service provided by drumstick + green gram – fennel cropping system is an economic benefit to society which is not provided by the traditional tobacco crop in the region.

Modified partial budgeting analysis was used to examine the economic viability of replacement of tobacco with drumstick + green gram - fennel cropping system. The debit side included what is lost in monetary terms due to the new cropping system, the credit side included what is gained in terms of tangible and intangible benefits as a result of implementing new technology. The debit side included, apart from the crop inputs used in technology, cost of technology generation and dissemination and interest and risk premium on expenditure. The credit side included environmental and resource conservation benefits apart from benefits of crop output. The intangible benefits included saving in natural resources like soil and water and mitigation of climate though soil carbon built up. Though the magnitude of this soil carbon that remains in soil after the crop harvest is difficult to apportion, the drumstick plants that remain in the field are presumed to sustain the soil carbon.

The drumstick based new cropping system, though accounts for higher input costs, gives higher returns over the existing tobacco cropping system. On debit side, the additional seed, fertilizer, chemical and labour costs worked out to be ₹ 2017/ha, ₹ 757/ha, ₹ 1720/ha and ₹ 8000/ha, respectively. Adding interest on working capital, management cost and risk premium, this works out to ₹ 15,149/ha. Cost on research carried out to generate this new technology at the research farm and extension cost for transfer of technology was added to debit side to complete the story. The potential area for new technology is about 12700 ha, which is the existing tobacco area in the western region. Cost of research worked out on hectare basis was ₹ 1000000 (including intellectual fee of scientists, technical officers, material used and labour costs) as taken from records and per hectare cost of research was found ₹ 79 (Table 3). Similarly, the extension cost for transfer of new technology comprised of costs of demonstration, number of demonstration required for the potential area, intellectual fee. This works out to be ₹ 530/ha (Table 4). The total cash out flow at debit side worked out to be ₹ 15,758/ha (Table 5).

The credit side included saving on irrigation cost, environment value and added returns from the new cropping system. There is health hazard from use of tobacco (John *et al.*, 5). However, this could not be accounted on credit side in absence of clear cut estimate on per hectare basis (Sung *et al.*, 11). The cost estimate of tobacco use for India worked out to be US $ 1.7 billion.

The credit side included reduced cost on account of irrigation worth ₹ 1130/ha and environmental and conservation benefits worth ₹ 657/ha and ₹ 3696/ha, respectively. In addition, the increased production benefits worth ₹ 22,243/ha was realized from the drumstick based production system. The total of credit side including saving in costs and added returns but excluding health cost saving, thus, worked out to be ₹ 27726/ha.

The difference in credit and debit side after accounting for all cash inflow and out flow worked to be ₹ 11968/ha. A positive value signifies economic viability of replacing tobacco with drumstick + green gram – fennel cropping system in central Gujarat.

Table 3. Cost of experimentation at research farm.

Description	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09
Intellectual fee of scientific & technical personnel (₹)	200000	150000	150000	100000	100000	175000
Consumables (₹)	5000	5000	5000	5000	5000	5000
Miscellaneous (₹)	3540	3540	3540	3540	3540	3540
Contingency (5%)	10500	10500	10500	10500	10500	10500
Total (₹)	219040	169040	169040	119040	119040	194040
Total (₹)						989240
Total Expenditure on experiment (₹) Say						1000000
Potential area for technology transfer (ha)						12700
Cost per ha (₹)						79

The sensitivity analysis performed with respect to change in important parameters resulted in positive values of difference in credit and debit values (Table 6) for all the parameters except for fennel yield and fennel output price. Only a reduction in both by half would make this new drumstick + green gram – fennel cropping unviable. However, the possibility of 50% decline from the given yield level is remote given the fact that this crop is mostly grown under irrigated conditions by the local farmers who have source of water, owned or purchased. This shows the viability of the drumstick based new cropping system even in the eventuality of worse conditions with respect to variation in drumstick price, technology domain area, risk premium and management cost. It may be mentioned, nonetheless, that market of drumstick may be a policy issues to be addressed before testing and large scale transfer of the new drumstick based cropping system in the region. Though sale of drumstick pods in both rural and urban markets takes place and Gujarat has been an exporter of

Table 4. Cost of technology transfer.

S. No.	Item	Value (₹)
1	Cost of one demonstration for 100 ha*	50000
2	Number of demonstration for potential area	127
3	Total demonstration cost	6350000
4	Intellectual charges/salary for extension, 127 days @ ₹ 3000/ day	381000
5	Total cost	6731000
6	Cost per ha	530

*Taken from actual cost of demonstration in Farmers' Participatory Action Research Project (FPARP) conducted by the centre

Table 5. Modified partial budgeting analysis to examine economic viability of replacing tobacco with alternative cropping system (₹/ha).

Debit side				Credit side			
What is lost due to new cropping system				**What is gained due to new cropping system**			
Added costs if any	Price/ unit (₹)	Qty	Value (₹)	Reduced costs if any	Price/unit (₹)	Qty	Value (₹)
Additional seed				Cost on irrigation saved			
A. Old varietal cost - tobacco	0.04	13000	600	Reduced irrigation	210	3	630
B. Improved variety additional cost				Reduced lab cost for reduced irrigation	100	5	500
Green gram	15	31.7	475.5	Health cost saved[$]			
Fennel	20	19.8	396	Environmental cost saved			
Drumstick	2	833	1666	Soil carbon value		LS	657
Added seed cost due to new cropping system (D1)			1937.5	B. Value of soil conserve		LS	3696
Additional fertilizers				**Total reduced cost (C1)**			**5483**
A. Tobacco				2. Added returns			
DAP	0	0.0	0.0	1. Tobacco crop	35	1476	51660
Urea	6	220.0	1320.0	2. Improved system			
Amm. sulphate	5	238.0	1190.0	Green gram	20	430	8600
Micronutrients	0	0.0	0.0	Fodder yield	0.50	860	430
B. Improved cropping System			0.0	Fennel	80	596	47680
DAP=	8.3	140.2	1162.0	Drumstick	10	1578	15780
Urea=	6	140.0	840.0	Fuelwood	0.25	1077	269
MOP=	12.5	77.4	967.3	Fodder	0.50	2287	1144
Amm. sulphate=	5	59.5	297.5	Added returns due to new technology (2-1) (C2)			22243
Additional fertilizers cost due to new system (D2)			756.8	**TOTAL CREDIT SIDE (C1+C2)**			27726

Additional chemicals	Price/ unit (₹)	Qty	Value (₹)		
A. Old cropping system	0	0	0.0		
B. Improved system					
Lindane	10	59.5	595.0		
Monocrotophos	250	4.5	1125.0		
Additional chemicals cost due to new system (D3)			**1720.0**		
Additional labour due to input application	100	30.0	**3000.0**		
Additional labour due to ouput harvest	100	50.0	**5000.0**		
Additional labour cost due to new system (D4)			8000.0		
Total additional cost (D1+D2+D3+d4)			12494		
Interest on additional working capital for 3 months @ 5%			156		
Management cost of additional working capital @ 10%			1249		
Risk premium of additional working capital @ 10%			1249		
Sub-total (₹/ha)			15149		
Research cost per ha[@]			79		
Extension cost for transfer of technology[*]			530		
TOTAL DEBIT SIDE			**15758**		
				Difference (Credit – Debit)	**11968**

@ Appendix I, * Appendix II

[$]Economic costs of tobacco use in India, which is US $ 1.7 billion (John *et al.*, 2009), cannot be apportioned to the benefit of the new technology alone, hence not considered.

this produce to Southern states in recent years due to loss of crop there, market intelligence need to be strengthened before scaling up this cropping system to larger areas.

The World Health Organization Framework Convention on Tobacco Control (WHO FCTC) negotiated under the auspices of the World Health Organization was developed in response to the globalization of the tobacco epidemic. Article 1 of the FCTC requires that the parties to the convention, among other measures, reduce the production of tobacco in their countries. The FCTC, therefore, requires that alternative crops to tobacco be researched upon so that the farmers who depend on tobacco for their livelihood, can have alternative sources of income. The framework for national action envisages finding an alternative crop to tobacco. Tobacco in India, as in many other countries, yields higher net returns per unit of land than most other cash crops, and substantially more than food crops. Yet, following the increasing health concern about tobacco consumption, the central Ministry of Agriculture has not launched any development scheme for the tobacco crop since the completion of the Seventh Five-Year Plan (1985-90). Further, the area under tobacco has shrunk substantially due to various reasons in Gujarat. Earlier, villages famous for tobacco like Sarasa, Od and Samarakha in Anand and Kheda districts used to have 100 per cent area under cultivation in tobacco. Now this area has shrunk to only 20 per cent. The tobacco yield has gone down to 700 kg per hectare from 1,000 kg per hectare in the last five years as per the national daily Business Standard, May 6, 2012 (http://www.business-standard.com/india/news/area-under-tobacco-in-gujarat-down-80/284118/). Under, this circumstances, the new cropping system fills

Table 6. Sensitivity analysis for change in parameters in respect of the new production system.

S. No.	Senstivity of parameters*	Debit side (₹)	Credit side (₹)	Difference (₹)	Remark (₹)
1	Drumtick price				
a)	Reduced by 50%	15758	19836	4078	Positive
b)	Reduced by 75%	15758	15891	133	Positive
2	Green gram price				
a)	Reduced by 50%	15758	23425	7667	Positive
b)	Reduced by 75%	15758	21275	5517	Positive
3	Fennel price				
a)	Reduced by 25%	15758	15805	47	Positive
b)	Reduced by 50%	15758	3885	-11873	Negative
4	Yield				
a)	Drumtsick yield declined by 50%	15758	19835	4077	Positive
b)	Green gram yield declined by 50%	15758	23210	7452	Positive
c)	Fennel yield declined by 50%	15758	3885	-11873	Negative
2	Target area for new technology				
a)	Target area (tobacco growing) reduced by 50%	15837	27726	11889	Positive
b)	Target area (tobacco growing) reduced by 75%	15994	27726	11732	Positive
3	Management cost as proportion of working capital				
a)	Taking management cost as 15%	16382	27726	11344	Positive
b)	Taking management cost as 30%	18257	27726	9469	Positive
4	Risk premium as proportion of working capital				
a)	Taking risk premium as 15%	16382	27726	11344	Positive
b)	Taking risk premium as 20%	17007	27726	10719	Positive

*while keeping other parameters at same level

the void and gives a ray of hope for the enterprising farmers of this region. With the announcement of tobacco free campaign in Gujarat (http://www.dnaindia.com/india/report_gujarat-govt-announces-tobacco-free-gujarat-campaign_1548963), the focus has come on an alternative cropping system.

The drumstick + green gram – fennel cropping befits the economically viable system for the people of this region. This cropping system, though accounts for increased input cost to the tune of ₹ 12494/ha, the increased returns from the cropping system alone was estimated to be ₹ 22243/ha, making the drumstick based cropping system profitable. However, generation of new technology entails costs on on-farm knowledge testing and its dissemination to the target area, putting extra cost to exchequer. This needs to be taken into account. Further, with the increased importance on environmental and conservation issues, it was thought imperative to include its valuation, to the extent possible, in the analysis. These issues were accounted for in the modified partial budgeting analysis by taking former on the debit side and latter, on the credit side. This resulted into enhanced expenditure with drumstick + green gram – fennel cropping system to the tune of ₹ 15758/ha on debit side. The saving in resources, environmental and production benefits, thus, worked out to be ₹ 27726/ha on credit side. The difference worked out to be a positive, that is ₹ 11968/ha.

CONCLUSION

Agricultural scientists in NARS constantly generate new technologies with large data base generated from the field experiments. However, these technologies need to pass the test of economic viability. The purpose of this paper is to assist the crop scientists in using a simple farm management tool such as the 'modified partial budgeting' framework to decide on the 'economic viability' of new technologists generated before their test in farmers' fields and subsequent transfer to the targeted domain area of the new technology. The drumstick + green gram - fennel cropping systems, has not only been found to be more remunerative than tobacco cropping

system but also this system provides environmental services in terms of soil carbon built up and nutrient saving in the soil. This holds promise for agro-ecosystem of central Gujarat, which has predominant tobacco mono cropping system that is averse to resource conservation. Even after considering the cost of generation and dissemination of the new cropping system along with the environmental and conservation benefits, the new cropping system turned out to be viable. This not only suggests the scope of the suggested alternative cropping system to tobacco mono cropping system in tobacco growing area but also make it legitimate effort in view of the national action framework to find alternative crop after signing the Framework Convention on Tobacco Control of World Health Organization.

ACKNOWLEDGEMENT

The authors thank the Director of the institute for providing required facilities and encouragement to do the research work at the Research Farm of the centre at Vasad. The funds provided by the institute to lay the experiment at the farm made it possible. The technical support provided by the staff of the centre is duly acknowledged.

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Received : October, 2016; Revised : November, 2018; Accepted : November, 2018