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How to double farmers' income

in sugarcane-based cropping system?

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*Sugarcane is grown in an area of about 5.0 million ha in both tropical and sub-tropical regions of the country. India is the second largest sugarcane cultivating country next to Brazil. Sugar industry is also second largest agro-based industry in India after cotton and textiles. Sugar from sugarcane crop is the main source of sweetener and contributes about 80% at international level,while remaining sugar is contributed by sugarbeet crop. Besides this, sugarcane is also used for making brown sugar (*khandsari*) and jaggery (*gur*) in the country. During white sugar production, by-products of sugarcane industry like bagasse and molasses are also produced. Bagasse is mainly used as fuel and also used for production of compressed fibre board, paper, plastic etc. Molasses is used in distilleries for the manufacturing of ethyl alcohol, butyl alcohol, citric acid and also used as an additive to feeds for livestock. Press mud-cake can be used as soil amendment in saline and alkali soils whereas its application on normal soils also increases the organic carbon content of soil besides supplying N,P,K,S and other micro-nutrients. In India, there are two distinct agro-climatic regions of sugarcane cultivation viz., tropical and sub-tropical region.*

Key words: Cropping system, Farmer, Income, Sugarcane

THE average sugarcane yield in the country is about 71 tonne/ha**.** The country had produced 25.12 mt of sugar during 2015-16. Presently, the 716 installed sugar factories are running in the country with crushing capacity to produce around 33 million tonne white sugar. The fluctuating trend in sugar production requires main focus on development of climate resilient technologies and adoption of advanced sugarcane production technologies in the country.

Sugarcane production and utilization

Sugarcane is multi-purpose crop and has economic values. It can be used for sugar production, jaggery production and chewing purpose. It can be a good option for the generation additional income to the sugarcane growers in the country. The percentage of white sugar production has increased during last 10 years while decreasing percentage in *gur* and *khansdari* production. During 2014-15, about 359.33 tonne of sugarcane was produced. Presently about 76% sugarcane produced in the country goes for sugar manufacturing, 12.8% to jaggery production and *khansdari* sector, and remaining 11.2% for seed, feed and chewing etc. Policies of liberalization like import of sugar from other countries directly or indirectly influence sugarcane farmers' interest in cultivation, income generation, sugar millers promotion for technological advancements, increasing crushing capacity of sugar mill, fluctuations of sugar prices and overall profit of the industry as well.

Cost of sugarcane cultivation in the country

Sugarcane is long duration crop and requires higher levels of nutrients and water for better growth and development. Crop yield is also affected by duration of the standing crop, soil, topography and other climatic factors. It is obvious that actual cost of production differs significantly in different states. The cost of production of plant and ratoon crops of sugarcane in different states is given in Tables 1 and 2. Thus benefits from the sugarcane cultivation can be analysed. Although, sugarcane crop production and marketing depends upon several factors viz., crop season, agro-climatic region, input cost, availability of labourers, availability of sugar mill in the area, distance from sugar mills/collection centre etc. Table 1 showed that the expenditures/ha excluding land lease charges are higher in Uttar Pradesh (₹ I65,000) and are closely followed by Bihar (₹ 164,441) in sub-tropical region whereas in tropical region, Karnataka (₹ 193,750) excelled in the cost of production of sugarcane plant crop. The gaps in average cane yields

Table 1. Cost of cultivation of sugarcane plant crop

States	Cost of production/q (₹)	Expenditures/ha excluding land lease charges (₹)	Attained cane yield at field (tonne/ha)	FRP/SAP (price/q)*	Gross Income (₹)	Net profit	B:C Ratio
Sub tropical region							
Uttar Pradesh	194.11	165,000	85.00	315 (SAP)	267750	102750	1.62
Bihar	223.72	164,441	73.50	230	169050	4609	1.02
Punjab	165.05	140,300	85.00	230	195500	55200	1.39
Haryana	135.47	100,252	74.00	230	170200	79948	1.69
Rajasthan	150.55	135,500	90.00	230	207000	71500	1.52
Asom	157.33	118,000	75.00	320	240000	122000	2.03
Tropical region							
Maharashtra	84.13	147,229	175.00	237.10	414925	267696	2.81
Andhra Pradesh	205.92	152,592	74.10	230	170430	17838	0.12
Karnataka	129.16	193,750	150.00	250	375000	181250	2.10
Gujarat	233.44	186,991	80.10	310	248310	61319	1.32
Tamil Nadu	93.47	135,073	144.50	285	411825	276752	3.04
Odisha	146,87	141,000	96.00	230	220800	79800	1.56

**Source*: http://agricoop.nic.in/sites/default/files/SugarNew29.pdf

in different states have been observed mainly due to planting season, duration of crop, maturity and environmental factors. This affect benefit: cost ratio of the crop. The higher benefit: cost ratio was recorded in Tamil Nadu (3.04) followed by Maharashtra (2.81). Variation in benefit cost ratio is directly influenced by FRP/SAP (price/q). It is recommended by Union Government and adopted and recommended by the state governments. It is privilege given to state government to encourage sugarcane cultivation and provide benefits to the sugarcane growers of the state. The Andhra Pradesh, Odisha, Bihar and Gujarat are facing difficulties in getting higher benefit: cost ratio in sugarcane ratoon crop. Adoption of improved technologies may certainly increase their farmers income.

Increase the cane productivity, sugar recovery and farmers income

Farmers are growing sugarcane crop to get more income with application of limited inputs or management. They have achieved higher income after adoption of advanced methods/package of practices of sugarcane cultivation. Some methods and techniques are being given here by which sugarcane growers not only to get more income but can double their income in different parts of the country. Generating more income from sugarcane cultivation by sugarcane growers on the principle of increasing crop productivity, reducing cost of cultivation and value addition in sugar products and allied products are discussed here.

Selection of improved sugarcane varieties: Under AICRP on Sugarcane, so far 115 sugarcane varieties are identified and out of them 53 have been notified and released for different sugarcane zones of the country. The improved sugarcane varieties are in higher cane yield, juice quality parameters viz., sugar content, sugar recovery and commercial cane sugar yield. Sugarcane varieties are also available showing tolerance under adverse climatic conditions like drought and flood. Selection of quality seed and zone specific varieties may yield higher as compared to local existing/ cultivating varieties. Sugarcane varieties have been widely adopted and occupied larger share in different zones viz. Co 86032 (70%) in peninsular zone, Co 0238 (35%) in North-West Zone and Central Zone, and CoLk 94184 (28%), BO 91 (20%), Co 6907 (20%) and Co Bln 9104 (18%) in Eastern Zone of country. Uttar Pradesh has achieved 1st rank in sugar production (8.7 million tonnes in 2016-2017) because of improved sugarcane varieties and their better management on farmers' conditions. It has also increased Uttar Pradesh average productivity (72.3 tonne/ha – 2016-17) and sugar recovery level up to 10.62% during current year. Adoption of sugarcane early maturing and high-yielding varieties such as Co 0238 and CoLk 94184 has contributed significantly in increasing cane productivity and sugar recovery of the state.

Trench method of planting: Earlier trench method of planting was usually adopted in coastal areas as well as other areas where the crop growth was very tall. Due to strong winds during rainy season, sugarcane crop may lodge. But now, this method of planting is being widely adopted in sub-tropical region also. Trenches are dug at a distance of 75-90 cm, with the help of ridger tractor mounted or by manual labourer. The trenches should be about 30 cm deep. The mixture of NPK fertilizers should be uniformly spread in the trenches and mixed thoroughly in the soil. Then setts are planted end to end method within the trenches made. Drenching of the setts is done with chlorpyriphos @ 0.05% to protect from the soil-borne insect pests. Trenches are filled up with loose soil after planting. The sugarcane cutter and planter developed by Indian Institute of Sugarcane Research, Lucknow can also be used for combining the operations of opening the furrows, placement of fertilizers and then planting setts in the rows. Paired row trech planting is done at 30:120 cm in subtropical India. However, in

Table 2. Cost of cultivation of sugarcane ratoon crop

States	Cost of production/qtl (₹)	Expenditures/ha excluding land lease charges (₹)	Attained cane yield at field (tonne/ha)	FRP/SAP (price/q)*	Gross Income (₹)	Net profit	B:C Ratio
Sub tropical region							
Uttar Pradesh	83.75	67000	80.00	315	252000	185000	3.76
Bihar	140.94	98664	70.00	230	161000	62336	1.63
Punjab	93.28	74627	80.00	230	184000	109373	2.46
Haryana	106.53	74571	70.00	230	161000	86429	2.15
Rajasthan	111.36	81300	73.00	230	167900	86600	2.06
Asom	125.17	87617	70.00	250	175000	87383	1.99
Tropical region							
Maharashtra	44.17	44179	100.00	237.10	237100	192921	5.36
Andhra Pradesh	170.99	105506	61.75	230	142025	36519	0.35
Karnataka	125	125000	100.00	250	250000	125000	2.00
Gujarat	180.24	132120	73.30	310	227230	95110	1.71
Tamil Nadu	87.20	124000	142.20	285	405270	281270	3.26
Odisha	177.58	103000	58.00	230	133400	30400	1.29

*Source: http://agricoop.nic.in/sites/default/files/SugarNew29.pdf

Maharashtra and other tropical regions spacing may be increased up to 150 cm. Trench planting avoids lodging of cane particularly in ratoon crop. Paired row planting is the best practice for surface drip irrigation system and involving maximum resource use efficiency and cane productivity. In sub-tropical India, 25 to 30% cane yield could be increased. However, the planting method is suitable for multi-ratooning system.

Irrigation water management: Sugarcane is an irrigated crop and requires 1,400-2,300 mm water in sub-tropical region and 2,000 to 3,500 mm in the tropical region to achieve better growth and development. Generally, to complete a crop cycle, 6 to 36 irrigations may be required depending upon the regions, soil type, planting seasons etc. Irrigation water should be applied at depth of 7 to 8 cm. Irrigation water requirement is varied with age and growth stage of the crop. In subtropical region, 6 to 8 irrigations are required to complete its life-cycle in a year. However, in tropical region, up to 36 irrigations may be required. Keeping the scarcity and importance of water, drip irrigation method is being adopted in different parts of the country. In drip irrigation, water is supplied directly to the root zone using a network of tubes and dippers/emitters nozzles placed along the water-delivery line. This involves precise control and manipulation of soil moisture temporally and spatially, which improves water economy, growth and ultimately crop yield. The uniformity of water application in drip irrigation would be as high as 95%, if the system is properly planned, designed and operated.

Integrated nutrient management: Sugarcane crop is perennial in nature and exhausts higher level of nutrients from the soil. Sugarcane yielding 100 tonne/ha removes 208 kg of N, 53 kg of P, 280 kg K, 30 kg of S, 3.4 kg of Fe 1.2 kg of Mn and 0.6 kg of Cu from the soil. Hence, soil has to be replenished to sustain the productivity of sugarcane with the said quantities of nutrients and maintain availability of micro-nutrients in soil before there critical limit like Fe (non-calcareous soil) 4.2 ppm, Fe (calcareous soil) 6.3 ppm, Zn (Loamy soils) 1.2 ppm, Zn (Clay soils) 2.0 ppm, Mn 2.0 ppm, Cu 1.2 ppm and Hot water soluble-B 0.44 ppm. In northern India, the N requirement of sugarcane is about 150 to 180 kg N/ha, whereas in southern India, it is 250 to 350 kg/ha. If soil test values are not available, apply 60 to 80 kg P_2O_5 and 60 kg K_2O/ha in north India and 100 kg P_2O_5/ha in southern parts of the country. Application of well decomposed farmyard manure/compost @ 10-15 tonne/ha or composted press mud @ 5 tonne/ha is also recommended. Soil application of *Azotobactor/Azospirillum* @ 10 kg/ha cfu 10^7 -10^9in two equal splits at 30 and 60 days after planting gave 25% saving in nitrogenous fertilizers. Sulphur (S) may be applied @ 40-60 kg/ha in sugarcane plant crop in sulphur deficient soils. Micro-nutrients fertilizers may be mixed with well decomposed dung manure or compost and applied as basal dose.

Integrated weed management: Being perennial nature of sugarcane, the crop is affected by weeds in all three seasons. So for the economic management of weeds in sugarcane, three hoeings during tillering stage at 45, 90 and 120 days of the planting are recommended. However, under limitations of manpower-availability and labour cost etc., pre-emergence application of either of atrazine @ 2.0 kg a.i./ha or metribuzin @ 1.0 kg a.i./ha(800- 1000 litre water/ha) followed by either of 2,4 D Na salt @ 1.0 kg/ ha(600-800 litres water/ha) or hoeing at 45 days after ratooning can be successfully practised. Further, trash mulching in rows after ratoon initiation is also a good option to control the weed growth.

Crop diversification (Intercropping): Sugarcane is a cash crop which gives income after a year. However, there is need to diversify the cropping system by introducing other economic and short duration crops either in a sequence or as intercropping. Intercropping generates mid-season income for sugarcane farmers to meet the expenses for sugarcane cultivation and also fulfils the household

Management practices for economically important sugarcane diseases and insect-pest as discussed here.

Sugarcane disease	Management practices
Red rot	Red rot is a fungal disease caused by the fungus *Colletotrichum falcatum*. The *management practices* - For planting use seed from absolutely disease free seed plot. Do not plant sugarcane in the disease affected fields for one year. Grow varieties fairly resistant to red rot. Crush the affected crop early and plough up the fields soon after harvesting the crop. Collect and burn the stubbles. Rogue out and bury or burn the diseased canes. Uproot the entire clumps and not merely the affected stalks. Do not ratoon the diseased crop.
Wilt	This disease is caused by *Cephalosporium sacchari* (earlier *Fusarium moniliforme)*. The affected stalks become light and hollow. The control measures against this disease are the same as those of red rot. As the causal fungus persists in the soil over long period, the affected field should not be put under sugarcane at least three years.
Smut	Smut is caused by *Sporisorium scitamineum (*earlier *Ustilago scitaminea)*. This disease is prevalent throughout the year but is severe from May to July, and again in October-November. Its incidence increases in the ratoon crop. Use only smut free canes for seed purpose. Reject even the healthy looking canes in the diseased stools or those growing in the vicinity of the smut infected clumps. Remove the smut whips gently (without shaking) after putting them inside a closely woven drill bag. Then uproot the entire diseased clumps and burn or bury them deep. Immerse the bag used for collecting the smut whips in boiling water for 5 min after every roguing of the crop. Do not ratoon the smut infected crop.
Ratoon stunting	A coryneform bacterium *(Clavibacter xyli)* has been found to be associated with the disease. The affected crop remains stunted with thin canes. The leaves are comparatively pale and the roots are poorly developed. The management practices are recommended for this disease are - do not use the diseased crop for planting, select the cane-seed from a vigorously growing and healthy crop, moist hot air treatment of seed canes at 54ºC for 4 hr is effective in destroying the causal organism and do not ratoon the diseased crop.
Grassy shoot disease	The disease is caused by mycoplasma like bodies. The affected plants give rise to numerous thin tillers, the leaves become reduced in size, thin and narrow and usually turn chlorotic. If the attack is light, one or two weak canes may be formed. Uproot and destroy the affected clumps immediately after appearance. The moist hot air treatment of the seed-canes at 54ºC for 4 hr inactivates the causal organisms of this disease. Its incidence increases in the ratoon crop, therefore, do not ratoon the diseased crop.
Red stripe	Red stripe is a bacterial disease caused by *Pseudomonas rubrilineans*. It appears during June-August. The affected leaves show bright red streaks which are long, narrow and run longitudinally on the leaf-blade, causing the rotting of tops in severe cases. Rogue out the affected canes and burn or bury them.
Pokkah boeng	This disease is caused by *Fusarium moniliforme*. It appears during rainy season from July to September. The young leaves in the top portion of the plant become chlorotic at the base and get distorted and shortened. They turn dark red and fall off gradually. In severe cases, the rotting of the top portion of the cane occurs. Remove the affected clumps and bury them.
Stinking rot	This rot is caused by *Pseudomonas aeruginosa*. The disease appears during the rainy season from July to September. The cane tops dry with the rotting of upper portion or the whole of the stalk. A diseased cane emits a foul smell. Rogue out and burn the severely attacked canes.
Yellow leaf disease	This disease is caused by a Virus. It is new emerging disease mainly in tropical region of the country. Only tolerant/ resistant varieties are recommended for its management.

Insect-pest	Management practices
Termite	The termite appears from April to June and again in October. It destroys the germinating buds and causes the drying up of shoots after germination. To avoid its attack, apply only well-rotten farmyard manure and remove the stubbles and debris of previous crop from the field.
Early shoot-borer	This pest appears from April to June and causes dry dead-hearts which can be easily pulled out. The management practices are: plant the crop early, i.e. before the middle of March and can apply 10 kg granules of Regent/Mortel/Rippen 0.3 G (fipronil) before the setts are covered with soil by planking.
Top-borer	This pest appears from March to October and causes severe damage between July and August. The central leaf of the cane top dries up and turns dark. The other typical symptoms are the shot-holes in the leaf, white or red streaks on the upper side of the leaf midrib and bunchy tops from July onwards. The management practices are - collect and destroy its moths and egg-clusters, cut the attacked shoots at the ground level from April to June, use Tricho-card having 20,000 eggs of *Corcyra cephalonica* parasitized (seven days old) by *Tricogramma japopnicum* per acre at 10 days old interval from mid-April to end-June.
Stalk borer	It is also known as *Tarai* borer: This pest is active throughout the year. The larvae overwinter in the stubble and water-shoots. The attack remains low during April-June and increases in July. Its incidence is highest during October-November. There are no outward symptoms of the attack of this pest. Entrance or exit holes on the attacked canes can be seen only after stripping. A larva sometimes damages up to 3 nodes and the cane may be attacked at several places. The management practices are: do not use the cane-seed from the infested field. Staple 40 *Tricho*-cards (5 cm x 2.5 cm) hard paper piece glued with 7 days old eggs of laboratory host, *Corcyra cephalonica* parasitized by *Trichogramma chilonis* to the under-sides of sugarcane leaves from July to October at 10 days interval. Each card should have approximately 500 parasitized eggs and be spread uniformally at 40 spots per acre. Normally 10-12 releases are required. Do not ratoon a heavily infested crop. Plough the affected fields, collect the stumps and destroy.
Whitefly	The damaged crop looks pale during August-October. The leaves turn black owing to the development of a fungus. The underside of the leaves is full of nymphs and pupae which suck the sap from the leaves. Spray the crop with 40 ml Confidor 200 SL (imidacloprid) in 150 litres of water per acre is recommended.
Black bug	The attacked crop looks pale. The black adults and pink young nymphs suck the sap from the leaf-sheaths. This pest is active from April to June. Spray the crop with 350 ml of 20 EC (chlorpyriphos) in 400 litres of water per acre with manually operated sprayer is recommended.
Pyrilla	*Pyrilla* reduces cane yield and sugar recovery heavily. When the attack is severe it becomes difficult to make *gur*. This pest appears in April-May and again in August-September. The leaves of the damaged crop turn yellow. Later on owing to the development of a fungus, the crop turns black and the tops become unfit for feeding to cattle. The incidence of this pest is particularly high in a luxuriant crop and in the interior of field. Effective management practices are not available to this insect-pest.
Sugarcane mite	The mite appears from April to June and feeds on the lower side of the leaves under a fine web. The leaves turn red and later appear to be burnt. The growth of the affected crop is retarded during the pre-monsoon period. Baru *(Sorghum halepens)* is the alternative host plant from which this mite spreads to the sugarcane crop. So destroy the weed, if growing near the sugarcane fields.

Table 3. Crop diversification for additional income generation in the country

Locations	Crops
Autumn planted sugarcane	
Shahjahanpur	Wheat, *lahi*, pea, potato
Lucknow	Wheat, *toria*, sugar beet, berseem, onion, lentil, garlic, *kalaunzee*, coriander, pea
Pantnagar	Wheat, sugar beet, lentil, *lahi*
Muzaffarnagar	Pea, gram, sugarbeet
Gorakhpur	Berseem, potato, wheat
Jalandhar	Sugarbeet, wheat, *rayatoria*, potato, maize
Sriganganagar	Sugarbeet
Pusa (Bihar)	Lentil, coriander
Spring planted sugarcane	
Lucknow	Cowpea, c*hari*, moong
Pantnagar	Onion, *moong*, *urd*, soybean, cowpea
Muzaffarnagar	Onion
Pusa (Bihar)	*Moong*
Hisar	*Moong*
Coimbatore	*Moong*
Anakapalle	*Urd, moong*, soybean, cowpea
Parbhani	*Guar*, cowpea
Sameerwadi	*Moong*, onion, ground nut
Padegaon	Onion, Lucerne, berseem
Akola	Groundnut

requirement of food, fibre and oilseeds (Table 3). The inclusion of short duration, high value crops in sugarcane-based production system as inter-and/or sequential crops holds great promise in increasing the land utilization efficiency, reducing the production cost, economizing the use of market purchased costly inputs and making the system sustainable.

Furrow irrigated raised bed technique for planting of wheat with sugarcane: This technique is recommended for western parts of Uttar Pradesh where sugarcane-ratoon-wheat rotation is predominant and planting of sugarcane is delayed (up to first week of May) due to harvesting of wheat crop. Late planting of sugarcane gives poor yield of plant crop because of reduced tillering period. In furrow irrigated raised bed (FIRB) system, 2/3 rows of wheat are sown on the raised beds in November-December and furrows are kept vacant for sugarcane planting. Sugarcane is planted at 60-65 cm/80-85 cm apart from furrows during February-March in standing wheat crop. Sugarcane gives about 30% higher yield than wheat-sugarcane sequential system without reduction in wheat yield. In this system irrigation is only applied in furrows. Thus, this technique requires less volume of water and 20% water saving can be made.

Integrated insect-pests and disease management: Sugarcane is an annual crop and attacked by number of insect-pests and diseases. They can cause economic and qualitative damage to the crop. Management of insect-pests and diseases of sugarcane crop is promising and selection of effective management strategy is equally important. First of all regular monitoring of crop is required. If crop is infected at negligible level, agronomical/cultural/mechanical practices should be adopted. If crop is grown in insect pests and disease prevalence area, prior management strategy is required like selection of resistant varieties, sett treatment with bio-control agents or agro-chemicals to minimize population of infection causing agents. In standing crop, management of insect pests and diseases is difficult. However, some agro-chemicals are recommended for their management. So agro-chemicals should be procured from registered agency or government organizations and methods should be understood properly.

Ratoon management: Sugarcane is vegetative propagated crop and also used as ratoon crop. Ratooning is a practice of growing a crop from the stubbles of previous crop. The purpose of adopting this practice is to achieve maximum benefits from a planted crop with limited application of resources like, seeds and sugarcane planting cost and labourers. Sugarcane ratoon crop saves cost on preparatory tillage and planting material. It gets benefit of residual manure and moisture. It matures earlier and gives more or less same yield as cane. Generally, only one ratoon crop is recommended for adoption because of incidence of insect - pests and diseases increases and deterioration of soil takes place. But in some parts of sugarcane growing areas in the country two to three ratoon are common.

Management practices

To get higher income from ratoon crop, following management practices recommended.

Trash management: Most of the farmer burn trash in field which can be conserved. As we know that trash adds nutrients to the soil after their decomposition. Remove the trashes and keep it near bunds till stubble shaving and off-barring operations are over and then spread it in the field. Trash mulching conserves soil moisture. Mulched trash can be incorporated into the soil at the earthing up.

Stubble shaving: This is an indispensable operation to raise good ratoon crop. The stubble protruding above ground level are cut close to the ground using a spade. It may induce underground buds to sprout and establish deeper root system. Apply chlorpyriphos 20 EC (1 kg ai/ha) in 800-1,000 litre water) after stubble shaving to minimize insect-pests in the field.

Off-baring or root pruning or shoulder breaking: Cutting sides of the ridges, loosening soils between ridges are the other important operations in ratoon crop. It may reduce soil compaction. It can be done manually or using plough or tractor mounted ratoon management device (RMD). The RMD can do harrowing, weeding, dispensing farmyard manure, pesticide, fungicide, fertilizers and earthing up in a single pass. About 1 ha ratoon field can be worked in 4 to 5 hr.

Harvesting of the cane crop: Harvesting of plant crop is done as per varietal schedule. In north India,

early varieties are harvested after 15 December. However, mid-late varieties take 11 to 12 months maturity time and should be harvested after 15 February to obtain higher sugar recovery and cane yield. Autumn planted crop in north India is harvested after 15 months in December-January. In tropical region, planting of crop influences the harvesting of crop. December planted crop is harvested in next December whereas February planted crop is harvested in next February in Tamil Nadu and Maharashtra. *Adsali* crop is harvested after 15 to 18 months of planting in Maharashtra.

Weed management of ratoon crop: Critical period of crop weed competition in ratoon crop is 90 days after ratoon initiation. Thus integrated weed control measures as recommended in plant crop may also be applied in ratoon crop to minimize the incidence of weeds. In ratoon crop, trash mulching also reduces weed infestation. However, after trash mulching, spraying of chemicals on sugarcane rows also controls the intra-row weeds. In such cases, post-emergence application of 2-4,D @ 1 kg ai/ha controls the broadleaved weeds.

Water management in ratoon crop: Sugarcane crop is perennial in nature and requires more water. First irrigation is recommended at 5 to 6 weeks after the harvesting of main / previous crop and then regular schedule of irrigation is followed as plant crop. The duration between the two irrigations are reduced in ratoon crop as compared to plant crop. However, after adoption of trash mulching, soil moisture is conserved and made available for longer period.

Nutrient management: Nitrogen requirement of sugarcane ratoon should be increased by 25% because of superficial roots in ratoon as compared to plant crop. Thus nutrient use efficiency of ratoon crop is poor. Other nutrients are recommended as given in plant crop.

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Success story

A salt –tolerant variety 'KRL 210 wheat' produces good yield

The Central Soil Salinity Research Institute (CSSRI), Karnal during 2013 to get advisory on soil sodicity, and produce quality seed of 'KRL-210 wheat' in farmers' participatory mode and enhancing his livelihood by developing his own seed network (farmer to farmer market). Shri Surjeet Singh, a farmer known for his grassroots innovations, and producing quality seed lives in village Baras, Karnal, has been sowing the CSSRI bred salt tolerant variety 'KRL-210 wheat' since 2013 with remarkable yield (64.55 to 70.75 q/ha) on soils characterized as slightly alkali (pH range of 8.45±0.15). He used to sow the seed of 'KRL-210 wheat' in salt affected soils between first to second week of November with zero or reduced tillage using seed-cum-fertilizer drill. To harvest bold grains of KRL-210 (for seed purpose) with enhanced number of tillers, he calibrated his seed-drill to sow KRL-210 variety with lower seed rate of 55 kg/ha at 18 cm row spacing as against the recommended seed rate of 100 kg/ha with 22 cm row spacing. Shri Singh reduced the nitrogen fertilizer by 10% (135-140 kg N/ha), but maintained 15% higher P (58-60 kg P_2O_5/ha) application. Although he has been applying 1-2 irrigation normally since past 15 years in any of the wheat variety, for example during 2016-17 he irrigated KRL-210 only once after 30 days of seed sowing after experiencing weather pattern. No subsequent irrigations were applied as moisture requirement was fulfilled with intermittent rainfall received with 6 rainy days (total 96.3 mm rainfall) between January and March 2017, and optimum moisture remained in the field till harvest of the crop. The crop was harvested on 4 April, 2017 and yield data was recorded. With variability of 3.63%, the average yield of KRL-210, in past five years (2013-2017), was observed to be 67.47q/ha and maximum yield of 70.75 q/ha during 2016-17. This could be possible owing to creative farmers' management practices, relatively more number of effective tillers in KRL-210 (452-476/m^2) and higher grain weight [(46.2-48.1 g/1000-grains) (during 2016-17)]. Performance of Surjit Singh's adaptations with KRL-210 resulted in almost 25-30.0 % saving of resources with better monitory returns (B:C) with MSP of wheat along with conserving natural resources and enhancing environmental sustainability. Other than routine sell on MSP, he has been selling KRL-210 as seed on an average 70-90 quintals every year with price ₹ 3,000/q, and could earn ₹ 195, 000/ha from seed through farmers' network.It is to highlight that other than using KRL-210 since 2013, Shri. Surjit Singh has been continuing his informal agronomic experimentations with less seed and water since last about one and half decades to cope-up with climate variability. Such informal agronomic experimentation led by him in association (2013-2017) with CSSRI for assessing sodicity, providing salt-tolerant wheat KRL-210, and farmer networking support, provide an example of co-production of adaptive knowledge for adapting abiotic stresses and enhancing livelihood resilience.

Adaptation practices of Shri Surjit Singh compared with other farmers' practices

Adaptation components	Sh. Surjit Singh's practice	Practices followed by other farmers
Variety	KRL 210	HD 2967
Seed rate (kg/ha)	55	100
Method of sowing	Zero till	Rotavator/Zero till
Spacing (cm)	18	20-22
Fertilizer application		
Nitrogen (kg N/ha)	135-140	165-195
Phosphorus (kg P_2O_5/ha)	58-60 kg	50
Irrigation (No.)	1-2	3-4
Yield (q/ha)	70.75	60
Cost of cultivation (₹/ha)*	12,986	18,855-19,238
Gross returns @ ₹ 1,625/q	114,970	97,500
Benefit : Cost ratio1	8.85	5.07-5.46

*Other input costs being considered common while calculating cost of cultivation under both the practices.

[1] This exclude the income generated from KRL-210 as seed sell for which this variety was adopted by Shri Surjit Singh