

Crop diversification

for a sustainable agriculture

S K Rautaray^{1*} and Swati Sucharita²

¹ICAR-Indian Institute of Water Management, Bhubaneswar, Odisha 751 023

²Institute of Agricultural Sciences, Siksha O Anusandhan University, Bhubaneswar, Odisha 751 030

Crop diversification is a component of conservation agriculture. It is useful in enhancing plant productivity, quality, health and nutritional value and/or building crop resilience to biotic and abiotic stresses. It reduces the risk of huge crop loss and provides ecosystem services such as pollination, carbon sequestration, nutrient cycling and biodiversity promotion. At regional scale, the objective of the Government is to reduce the regional dominance of one crop to regional production of a number of crops. However, the importance of crop diversification is often overlooked due to profit motive from crops such as rice, wheat and sugarcane having assured market with the provision of minimum support price. Considering the importance of crop diversification, several Government programmes are under implementation. Ways for popularizing crop diversification is outlined in this article.

Keywords: Benefits, Crop diversification, Ecosystem services, Government programmes, Popularising

CONSERVATION agriculture refers to the farming practice of conserving natural resources (soil, water, biodiversity) for a sustainable agriculture. The three basic principles of conservation agriculture include crop diversification, minimal soil movement, and soil coverage with residue of the previous crop, cover crop or both. Crop diversification refers to a shift from one crop to another. It aims to grow agroecologically suitable different crops in a field over space and/or time. Examples of diversification over space include substitution of rice crop in *kharif* season with maize, millets, soybean, groundnut, sunflower, vegetables, pulses etc. in uplands of high rainfall regions or in medium lands of low rainfall regions. Similarly, examples of diversification over time include intercropping of mustard in wheat, sesamum in sugarcane (at planting time), sunflower in sugarcane, red gram in upland rice, and groundnut in maize/sorghum/bajra/

upland rice. Varietal or genetic diversification refers to growing of different varieties with diverse tolerance/resistance to a stress, so that large scale damage is avoided in such event. Crop diversification is in contrast to monoculture in which a single crop dominates the cropping scenario over years, mainly based on profit motive. Examples include rice-wheat in Indo-Gangetic plains, sugarcane in Maharashtra and Western UP, and rice-rice in Assam, West Bengal, Bihar, Eastern UP, Odisha, Andhra Pradesh, and Tamil Nadu.



Substitution of paddy with groundnut in a medium land in low rainfall area



Intercropped sunflower reached flowering before grand growth stage of sugarcane

At field scale, the main objective of crop diversification includes improving soil health and biodiversity, and reducing pest (insect pest, disease and weed) load. Overall, this will help in arresting yield decline. At regional scale, the objective of the Government is to reduce the regional dominance of one crop to regional production of a number of crops. This will help to produce millets, pulses, oilseeds, vegetables, fruits, fibres, fodder, and grasses with the objective of self-sufficiency, and reducing

the pest load and import bill on oilseeds and pulses. The adverse effect of paddy monoculture in canal irrigated area in terms of waterlogging and salinity can be avoided by crop diversification. The other important objective is to arrest the groundwater decline. This can be achieved by substituting the water guzzling crops such as rice, sugarcane and banana with water conserving crops.

Importance of crop diversification is often overlooked due to profit motive from crops such as rice, wheat and sugarcane having assured market with the provision of minimum support price. Good yield is obtained from these crops by using high fertilizer dose, irrigation water and pesticides. Huge subsidy on fertilizers and free or subsidized electricity for pumping water encourages for cultivation of these crops in large scale leading to promotion of monoculture. However, it is high time to understand the adverse effects of input intensive monoculture and importance of crop diversification for a sustainable agriculture.

Benefits of crop diversification

Reduces the occurrence of pests and diseases by interrupting their life cycles: From our experience with the brinjal-tomato sequence, there was heavy incidence of bacterial wilt in tomato crop. Tomato plants wilted and died in spite of multi-prong control measures incurring heavy economic burden and harmful chemical load to the environment. On the other hand, there was little wilt in tomato with the plot under millet-tomato sequence. Solanaceae family crops such as potato, tomato, chili, brinjal and vegetable should not be grown in sequence over years in order to reduce the common pest and disease problem. Thus, crop diversification with millets and other crops is suggested in spite of short term low return. Net return over years, pollution load and soil health suggest for crop diversification and sustainable agriculture.

There was buildup of stem borer population with rice-rice sequence as compared to rice-fallow or rice-



Wilting and dying of tomato under brinjal-tomato sequence



Healthy tomato crop without wilt under millet-tomato sequence

upland crop sequence. Rice stem borer is a regular pest in lowland rice with less than 5% economic loss in traditional rice-fallow system. With the availability of irrigation water, farmers prefer rice-rice crop sequence in eastern and southern parts of India. With the host availability for two crop seasons, stem borer incidence has increased. This invites heavy pesticide spray leading to high cost of cultivation, pesticide load to environment and biodiversity decline. In Assam state, rice is grown in *Ahu* (pre-kharif), *Sali* (kharif) and *Boro* (rabi) seasons. This creates rice growing environment round the year. It was observed that after the late harvest of *kharif* rice and deep-water rice (*Bao*), adult moths lay eggs on the leaves of *Boro* rice

nursery. Thus, there was no need of pupation of this insect between two seasons. Heavy infestation of stem borer in *Boro* rice nursery and in main field was observed under rice-rice sequence, especially with the *Bao-Boro* sequence. Thus, after the harvest of *kharif* rice, some non-rice crops such as sunflower, toria, grass pea, radish, late season potato etc should be grown in medium lands.

Weed management

Rice monoculture invited grassy weeds (weedy rice, *Echinochloa colona*, *Echinochloa crusgalli*, *Echinochloa glabrescens*), sedges (*Cyperus difformis*, *Cyperus iria*) and broad leaf weeds (*Alternanthera sessilis*, *Ammania baccifera*, *Eclipta prostrata*, *Ludwigia octovalvis*, *Sphaenochlea zeylanica*) in

medium lands. Rice monoculture promoted *Monochoria*, *Chara*, *Nitella*, *Hydrilla*, *Ludwigia* and *Ipomoea* under lowlands. It was observed that growing of *Sesbania* as cover-cum-green manure crop before rice reduces weed population due to allelopathy and/or smothering effect. Crop diversification using sunhemp (*Crotalaria*) under uplands and *Sesbania* under lowlands is useful in weed management in addition to nitrogen fixation and promotion of earthworm population.

Wheat monoculture promoted Poaceae weed *Phalaris minor*. Growing environment and crop morphology of wheat and the weed being similar, it is an associative weed of wheat crop. This weed produces 10,000 to 30,000 seeds per plant as compared to only 60 to 80 seeds for wheat. Monoculture of wheat has favoured huge weed seed bank and now it is difficult manage this weed. Crop diversification with mustard, French bean, field pea etc. is easy and safe way of managing this problematic weed.

Adequately distributes nutrients in soil profile: Crop diversification with legume crops help in nitrogen fixation and thereby leave residual N in soil. When legume crop residues are incorporated into soil, there is quick release of nutrients due to high nitrogen content as compared to carbon content. Similarly, inclusion of deep rooted crops helps to recycle nutrients which were leached beyond the root zone of shallow rooted crops. Also, crops differ in nutrient demand. Cereals and banana have high demand for nitrogen and potash; pulses have high demand for calcium, phosphorous, molybdenum and cobalt; and oilseeds have special requirement of sulphur and calcium. Growing diverse crops in rotation helps in efficient utilization of these nutrients from soil profile.

Efficient utilization of soil water: Crops differ in rooting pattern and depth. Crop diversification using deep rooted crops (Alfalfa, redgram, corn, cotton, melons, pumpkin) help in using soil moisture from deeper layers. In water deficit areas, C4 plants (Sorghum, bajra, sugarcane,

millets and switch grass) and CAM plants (Pineapple, Agave, Opuntia, Dragon fruit) are suitable. Among the C3 plants, short duration crops and plants having tolerance to moisture stress (millets, moth bean green gram, black gram) can be used in crop diversification programme. Moderately deep rooted watermelon crop when planted early in the season could grow using residual soil moisture and supplemental irrigation.

Maintains dynamic equilibrium of the agro-ecosystem: Crop diversification helps to increase natural biodiversity, which is useful in strengthening the ability of the agroecosystem to respond to biotic and abiotic stresses. We experienced increase in earthworm population and diversity with the growing and incorporation of cover crop biomass. Crop diversification helps in increasing microbial diversity in soil. Natural predators and parasites in agroecosystem are expected to be conserved by including crops requiring minimal use of pesticides (millets, pulses and oilseed crops).

Reduces economic risk: Large scale monoculture results in production of few crops. This results in marketing problem. Break out of disease or pest problem may result in huge loss in monoculture. However, crop diversification is beneficial in avoiding such problems and thereby reducing economic loss.

Allows a balance in residue production: Cereals leave more residue than pulse and fodder crops. Rice straw management before wheat sowing is sometimes problematic due to huge residue production. Similarly, sugarcane and banana generate huge crop residue. Crop diversification can avoid such problem.

Reduces climatic risks: Terminal heat stress in wheat reduces grain yield. Large scale wheat monoculture may suffer huge loss in years of terminal heat stress. Hailstorm at ripening and maturity results in huge loss. Certain pest and disease outbreak is related to climatic factors. Crop diversification reduces such risks.



Early planted watermelon for efficient use of soil profile moisture

Government Programmes

Crop Diversification Programme (CDP) is a sub scheme of *Rashtriya Krishi Vikas Yojana*. It is being implemented in Punjab, Haryana and Uttar Pradesh to replace a part of the area under paddy to alternate crops. Under the programme for replacing paddy crop, assistance is provided for four major interventions viz. alternate crop demonstrations, farm mechanization and value addition, site-specific activities, and contingency for awareness, training, monitoring, etc. In addition, the states can promote crop diversification with the approval of State Level Sanctioning Committee headed by the Chief Secretary of the State. In tobacco growing Andhra Pradesh, Bihar, Gujrat, Karnataka, Maharashtra, Odisha, Tamil Nadu, Telangana, Uttar Pradesh, and West Bengal, State Governments are given flexibility to take suitable activities/interventions for growing alternative crops. Punjab Government has implemented '*Pani Bachao Paise Kamao*' scheme since 2018 to prevent groundwater overexploitation due to paddy cultivation. Also, Punjab Preservation of Subsoil Water Act, 2009 prohibits transplanting of paddy before 10th June to control over-exploitation of groundwater resources due to paddy cultivation. Haryana Government since 2020 is providing incentive of ₹ 7,000 per acre to farmers for diversifying more than 50% of their *kharif* season paddy area. Government of Maharashtra has prohibited sugarcane cultivation without adoption of drip irrigation.

Ways for popularizing crop diversification

- Identifying crops which provide higher net return as compared to the prevailing crops
- New crop should be acceptable to farmers with stable yield
- New areas of crop diversification should be explored. Bund crops (planting of black gram or red gram on bunds of rice field), alley crops, relay crops, catch crops, bee crops, trap crops, mixed crops, and inter crops have potential role in crop diversification.
- Crop diversification in water scarce areas can be popularized by using micro-irrigation. Responsive crops such as tea and close spaced crops should be identified for sprinkler irrigation. For drip irrigation, potato, tomato, sweet potato, chilli, banana, papaya and fruit crops should be identified.
- Integrated farming system embracing suitable crops should be promoted.
- Subsidy on solar pump with micro-irrigation should be prioritized for the crop diversification programme.
- Strengthening marketing facility for crops grown under crop diversification.
- Priority in export of produce grown under crop diversification.



Red gram on rice field bund under medium land situations



Crop diversification with rice-fish integrated farming system

CONCLUSION

Crop diversification has a significant role in yield stability and ecosystem services as compared to short term benefit from monoculture. There is huge risk of crop loss and adverse effect on environment from monoculture, especially under climate change scenario. At regional scale, the objective of the Government is to reduce the regional dominance of

one crop to regional production of a number of crops. It is high time to reduce the huge burden on foreign exchange for importing pulses and oilseeds. So, Government of India and state Governments are implementing crop diversification programmes in wide scale. Identification of alternate crops to monoculture is location specific and need to be identified. Bund crops, alley crops, relay crops, catch crops,

bee crops, trap crops, mixed crops, and inter crops under integrated farming system mode have potential role in crop diversification. Micro-irrigation methods and responsive crops has also role in promoting crop diversification.

*Corresponding author e-mail:
sachin.rautaray@icar.gov.in



**Plant trees, Conserve water,
Protect environment.**

