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Resource management and input endowment in organic arable crops production: Considerations and constraints

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Abstract
In this review different aspects of crop management were reviewed with respects to considerations and constraints. The organic farming was specialized commercial farming with positive bias towards the health of natural resources and involvement of sustainability components. The organic farming at present discussed in terms of identification of new niche area for organic farming for different crops, modification in certification process such as waiving off certification process of few states from North East Hill (NEH) region and up gradation to meet the international standards, value addition in organic resources available for nutrient endowment in organic farming, weaning of organic inputs from other competitive uses, seed production in organic farming, development of rural entrepreneurship through input production in organic farming, empowering FPOs as organic farming entrepreneur, yield maximization in organic farming and production of different biodynamic formulations at larger scale for organic farming. The nutrient endowment and pest and disease management were the more frequently discussed considering their role in certification processes and impacts on crop production and quality. Besides that, seed and sowing specifications as well as weed management also needed modification to suit for organic production system. The number of input sources, availability of suitable alternative to inorganic chemicals, cost effectiveness and changes in productivity and quality were the major point of research and policy development.

Keywords: Nutrient management, biological control, certification, seed production

1. Introduction
The use of organic matter as a source of crop nutrition was mentioned in *Rigveda* and *Yajurveda* and all agricultural activities were organic before invention and use of agrochemicals in 18th century (Nene, 2006 and 2012; Kaur, 2014; Beniwal *et al*., 2020) [37, 29, 8]. The realization and quantifiable evidences of adverse effect of continuous and indiscriminate use of agrochemicals on foods web (Carvalho, 2017; Sarker *et al*., 2020; Dhiman *et al*., 2024) [11, 52, 17] and increased footprint of modern agricultural activities on natural resources (Khan and Hanjra, 2009; Gomiero *et al*., 2011; Voronkova *et al*., 2019; Fanelli, 2020) [30, 25, 64, 22] act as precursor for 'U' turn from conventionally followed inorganic (agrochemical based farming system) farming to market oriented commercial level organic farming (Valencia *et al*., 2019; Dhiman, 2020; Sapbamrer and Thammachai, 2021; Ramanjaneyulu *et al*., 2013) [62, 18, 51, 43]. The organic farming getting momentum across the world due to several factors such as availability of large land per capita in countries such as Australia, increased demand of organic products (especially from developed countries), increasing purchasing power and increasing population under middle income groups from developing countries (larges expected domestic market), policy interventions leading to ease in certification process and exports of organic produce (Vashishat *et al*., 2024; Priyadarshini and Abhilash, 2020; Ferdous *et al*., 2021) [63, 42, 23]. Besides these factors other factors such as institutional development leading to bring uniformity in recommended practices for organic farming, promotion followed by private sector initiative in input production for organic farming, national as well as regional governmental schemes for promotion of organic farming, emergence of new organization setup such as farmers producer organization (FPO) (Gautam and Mallaiah, 2024; Gurung *et al*., 2024; Bhadwal *et al*., 2022) [24, 27, 9], organic food chains and initiatives of different international and national brands for organic products.

Several changes are occurred in organic farming practices followed at present over organic farming followed before industrialization to made organic farming economically viable. These changes occur in input additions and their management. The changes occurred has both constraints and potentials due wider adoption of agrochemical based modern farming system and lack of firm and widely adaptable knowledge for recommendation in organic farming. Besides that, availability of resources as well as lack of measures for management of different insect-pest and diseases to reduce economic losses also adds to constraints. The major niche area of organic farming in India is semi-arid and arid area in inland and hill ecosystem in India. In both these area, resources are constraints due to natural phenomenon such wind and water erosion (Saha *et al*., 2012; Yadav *et al*., 2020) [49, 66], poor soil fertility due to less addition of organic matter (Sreenivas *et al*., 2016) [59], quick fading of organic carbon due climatic condition and dependency on rainfall. Out of the total organic farming area, 17.5% is in North East Hill region with two organic states *viz*., Uttarakhand and Sikkim and 50% was represented by Maharashtra, Madhya Pradesh and Rajasthan. Along with this natural phenomenon other constraints are small crop produce making marketing difficult as well as non-availability of market chain for organic crop produce. Comparing organic and conventional agrochemical based farming (Alvarez, 2022; Kilic *et al*., 2020; Rualthankhuma and Sarkar, 2011) [4, 31, 48], pros and cons of organic farming (Reddy, 2022) [45] as well as scope of organic farming were describes at different scale and still these aspects being explore in future. The constraints and concerns of crop production in organic farming are yet not completely explored and need to be addressed. In this context, it is needed to discuss about the constraints and challenges in organic farming and avenues for tackling these constraints. Hence, different aspects of crop management were reviewed with respects to considerations and constraints in this review.

2. Organic farming: An overview

Organic farming is a specialized type of commercial farming driven by market demand and also has positive bias towards maintaining the natural resource base. It is also considered as one of the first attempt to put price tag on natural resource considering their premier market prices and practices followed which avoid damage to natural ecosystem. It is an umbrella terms for different types of farming such as perma-culture, permanent agriculture, biodynamic farming, biological farming, natural farming, Eco-farming, alternate agriculture, integrated intensive farming system, low external input sustainable farming system, Panchgavya Krishi, *Rishi* farming and Natural Ecological farming (NatuEco farming)**.** International federation on organic agriculture movement (IFOAM) define organic farming as “organic agriculture is a production system that sustains the health of soils, ecosystems, and people. It relies on ecological processes, biodiversity and cycles adapted to local conditions, rather than the use of inputs with adverse effects. Organic Agriculture combines tradition, innovation, and science to benefit the shared environment and promote fair relationships and good quality of life for all involved”; while at national level, national programme on organic production define organic farming as “organic agriculture is a system of farm design and management to create an ecosystem, which can achieve sustainable productivity without the use of artificial external inputs such as chemicals, fertilizers and pesticides”. The organic farming avoids or put severe restrictions on use of agrochemicals, avoids use of antibiotics as well as genetically modified crops. The increase in area under organic farming showed its prospects in future (10.17 m ha with 5.39 m ha as cultivated area and 4.78 m ha wild forest collection as on March, 2023 as reported by APEDA); while suitability of few niche areas for organic farming where modern agrochemical based farming system will not work indicates need of organic farming in such area (North East Hill Region). The old phrase “several farmers are organic by default in India” will not hold true at present and future due to increase interest of stake holders in organic farming and different form of organic farming (such as rooftop farming, vertical farming, natural farming, etc.). Though organic farming can be possible in all crops, it is commonly followed in oil seeds, fibre, sugarcane, cereals and millet, cotton, pulses, medicinal and aromatic plants, tea, coffee, fruits, spices, dry fruits and vegetables crops considering their market demand. Other factors affecting selection of crops are availability of certification agency, specialization of farmers in growing particular crop, availability of processing facility and suitability of crop for processing, easy access to market and export potential. The area under organic farming is classified in to two different types *viz*., cultivated area and forest collection. Out of these two types 4.47 m ha area (96.4 m ha in world) is cultivated area for which both recommended practices and certification process is pre-planned and traceable; while for forest collection area is 2.85 m ha in India (Anonymous, 2024 and Willer *et al*., 2024) [3, 65]. The growth of area under organic farming at present over 2021-22 was 26.6% in the world and 77.8% in India. The certification process for forest collection is largely excluded as production process is natural with less human interference. The organic farming is also treated as diversified farming system, market (export) oriented farming, environmentally responsive farming and climate resilient farming due it its principles, practices and recommendations. This diversified nature of organic farming indicates it significant place in future agriculture.

3. Major changes in organic farming over conventionally followed agrochemical based conventional farming system

The concepts such as sustainability in agro-ecosystem and environmental friendliness are major considerations making organic farming different from conventionally followed farming in early days of promotion of organic farming; while premier prices of organic produce, higher market demand and increased awareness about agrochemical residue in conventionally produced food and their impact on human health at commercial level making organic farming differ from conventional farming at present. At the same time, care for both living as well as non-living components involved in the farming activity make organic farming differ from conventional farming. The increase in opportunity for enterprise diversification and integrated farming system based approach to harvest positive interaction between different components involved in farming system are also predominated by most of the principles of organic farming making it differ from conventional farming. The organic farming is also free from natural manipulation due to restriction on use of transgenic crops and antibiotics to influence crop production. The biomagnifications of heavy metals in humans due to use of untreated waste and sewage sludge as crop manure is prevented in organic farming due to restriction on their use. Besides that, variation in yield is major factors differentiate organic farming. The studies conducted to compare organic farming with conventional farming showed 20% (De Ponti *et al*., 2012) [15], 36.1% (Li *et al*., 2019) [36], 13-34% (Seufert, 2012) [54] reduction in yield in organic farming. The meta analysis conducted by

Knapp and Heijden (2018) [32] showed types of crop, nitrogen and phosphorus fertilization and tillage are the reasons for variation and stability in production with use green manures and enhanced green fertilization as a way for reducing the yield stability gap between organic and conventional agriculture. The variation in regulation across the countries for input use, impact of land holding, still dependence of forest collection for organic farming, non-accountability of non-certified area, difference in quantity of nutrient added and soil fertility variation and crop/species/variety response to organic inputs and management also respond to variation in yield across the system. The economics of organic farming regards to cost of cultivation was found inferior to conventional farming while the premier prices of organic produce are reality over conventional produce; while in local market such increase is conditioned by several factors (Durham *et al*., 2021) [20]. Besides that, area which are dominated by organic production system either due to environmental condition or by incompetency in utilizing the modern agrochemical based agriculture do not have such premier prices and North East Hill region of India is one such example. The pricing system in organic farming is governed by market availability and domestic and international market demand. This higher price increase net returns and need to be considered while calculating returns from organic farming to get clear idea about organic farming economics. The higher prices of organic inputs, use of same prices of output while comparing returns, lack of avenues for efficient and timely (quick) in-season correction of pest and disease incidence and other stresses and low and variable nutrient content in organic manures are also responsible for lower returns in organic farming system. The product diversity is also higher in case of conventional farming due to availability of large array of crops, processing units and freedom to use preservatives; while in case of the organic farming, independent processing unit establishments and their functioning throughout the year is difficult task considering the availability of raw material and their sparse distribution across the different part of the country. The organic products are reported to be free from the residue of agrochemicals with some additional advantage in term of nutrition; while as nutrient taken in the form of ions of elements which is not affected by source of crop nutrition and as uptake of nutrient is function of crop physiology (Ideotype), its nutritional superiority is debated with large number of opinion of difference.

4. Resource endowments and management in organic farming

Due to conditions and specifications on use of inputs, the management practices need modification and modulation in organic farming. At the same time, considering the standard of organic farming and influence of adjoining agricultural farm and their activities, following organic farming on either entire zone/ small part of region continuously or on large block is more suitable to avoid the dilution of organic standards rather than in isolated field. As the resource management practices had direct impact on the yield and quality of organic produce, the describing these practices are of economical and ecological significance. This section in details discuss about consideration, constraints and potentials of differ alternatives/interventions in input endowment and their management in organic production system (Table 1).

4.1 Considerations for selection of crops/seeds/variety for organic farming

The consideration for selections of crops and variety has practical significance due to below mentioned interventions. The major constraints and considerations is related with organic seed availability. The crop/ variety selected need to have organic certified seed available in market. If such seeds are not available then seed produced by conventional methods (without any agrochemical treatment) need to be used. At the same time, selected crop/ variety seed should not be genetically modified (as GM crops are not allowed in organic farming). The attention should be given for maintaining the genetic diversity of crop. The selected crop/ variety need to have quick growing ability and cover the ground. This leads to increasing competitive ability of the plant against weeds. At the same time, crop which having allelopathic effect on the weeds such as sunflower, mustard and maize may be considered. The crop/varieties which are responsive to mechanical soil manipulation including in-season tillage need to be selected (No damage by root cutting). The crops/varieties selected should have resistance to major insect-pest and diseases occurring in particular area. This will help in reducing the attack of insect-pest and disease thereby reducing the need for management practices them in growing season. With regards to morphological attributes, the selected crop/ varieties should have deep and well developed root system, high nutrient acquization capacity, high nutrient uptake, ability to transfer nutrient from different plant parts to economic plant parts (Crop/variety with high harvest index will serve the objective) and higher bioavailability of nutrients. Sometime selections of local varieties or varieties with some special character such as Basmati rice, scented rice are valid way. Black (medicinal) rice, etc. need to be considered. As these varieties produces distinct quality seeds with higher market price and suits to high purchasing power section of population. The crops/ varieties selected should have positive interaction with soil microflora. This will helps in increasing the nutrient acquisition capacity of soil. The crop and variety selected should be suitable for processing and value addition (High purchasing capacity of targeted consumers and hence preferred to buy the processed products). For cultivation in organic farming the crops/ varieties which having higher or superior qualities should be preferred then crop/ varieties having higher yield. The crops/ varieties having higher total biomass production may be considered as break crop in organic farm. As such crops/ varieties add large amount of dry matter which act as source of crop nutrition. The selected crops/ varieties should have longer storage life/ post-harvest life. This makes it possible to transport these crops/ varieties for longer distance (export potential). The crops/ varieties having consumer preference should be selected and market demand need to be considered. The selected crops/ varieties with easy certification process and agencies are available in vicinity should be considered. The selected crops/ varieties are commonly grown in locality as well as if any special inputs required then it should be available in the vicinity.

4.2 Constraints for water management

The water management do not have many considerations in organic farming except its inherent quality and admixture due to inorganic materials. Beside these restrictions, the use of irrigation water will be an essential for harvesting positive interaction of input addition/crop management with water thereby enhancing the productivity of organic farming. The free flow irrigation has restrictions (commonly followed in rice) as water may flow from conventionally grown rice to organic rice field and carry agrochemicals along with water and eroded soil with water. Provision of separate irrigation channel is worthy if adjoining fields have agrochemical application (especially drenching through irrigation channel and soil application of agrochemicals). This also helps in application of biodynamic formulation through irrigation channels. Analysis of quality of irrigation water is needed if field are in peri-urban area, where dumping of sewage water and other waste may reach to groundwater and pollute it. In such case, growing of non-food crops or using such land for conventional agrochemical farming is worthy. The use of sewage water or water from effluents of chemical company high in heavy metal is not-permitted in organic farming even though they may supply nutrients and/ or treated to remove heavy metals.

4.3 Constraints in weed management

At present, weed management through herbicide is considered as most economic considering its time, labour and economic efficiency; while the higher wage rates, constraints in use of mechanical tools and variable economic efficiency of other methods of weed management make herbicide more adaptable. The inability of biological methods to control composite and dynamic weed flora are other reason for making chemical weed management more economical for conventional farming. In case of organic farming, mechanical method of weed management is having highest potential due to timeliness of operation and assurance to control composite weed flora. Kristiansen *et al*. (2001) [33] reported that out of 219 organic horticultural grower surveyed for study of the methods of weed management, more than 90% grower responded hand weeding and 75 to 80% growers responded that organic mulch will the method used for management of weed in organic horticultural crops. Tillage and slashing/ mowing rank third and fourth with 70% and 65-70% responds use these methods. The changes in crop density and solarisation do not received any significant place among the respondents. Using small tools for weeding is suitable for marginal land holding (<1 ha.); while significance of mechanical or battery operated handheld machines were preferred on large holding. The tools such as different hand hoes (such as junior hoe), dry land weeder (peg tooth and star wheel type), sweep, ridger, wooden plough and engine operated weeder are common in use; while puddler and cono weeder are common in rice. Besides that, cultural and preventive measures carry significant importance considering few options for in-season weed management in organic farming. Dixit *et al*. (2015) [19] reported significant impact of tillage on weed dry matter and density in chickpea-fodder sorghum cropping system. They found that weed dry matter was higher in both crops at 75 DAS in reduced tillage compared to conventional tillage (average of three years data) with marginal yield gain of 20 kg ha^{-1} and net returns of Rs. 3139 ha^{-1} in reduced tillage over conventional tillage. The significant effect of paddy straw mulch (at 5 t ha^{-1}) and wheat straw mulch (5 t ha^{-1}) on reducing weed density and weed dry matter was reported at 60 DAS in chick pea was reported by Sahu *et al*. (2022) [50]. The positive effect of mulching and intercropping on weed management under organic wheat cultivation was reported by Kumari *et al*. (2019). The positive effect of cultural practices such as tillage and mulching (Chethan *et al*., 2023) [12], intercropping, brown manuring and stale seed bed preparation helps in reducing weed problem (Table 2).

4.4 Insect-pest and disease management

The losses caused due to insect-pest and diseases were 22% and 29%, respectively out of the total losses caused by different stresses in the crop cultivation. The major management strategy developed for their management is dominated by agrochemical and is more efficient, timely and economical to stake holders. The different avenues for pest and disease management in organic farming had least efficient and several cases fail to achieve the required control. The adoption of preventive and cultural practices are constrained due to non-willingness on investment before any pest and disease occurs and non-usefulness in case of incidence of pest and disease in moderate to severe form. The positive point of cultural practices such as multiple uses, least cost involvement, traditionally followed with indigenous technical knowledge, on-farm availability and ease in practice make these practice a suitable and valid alternative. The biological methods of pest and disease management are getting highlighted with identification and development of different botanicals (Lengai *et al*., 2020) [35] although they have limitation (Damalas *et al*., 2020) [13]. The documentation and distribution of different ITK based product/knowledge and availability of different spray based biological formulation (Devapatni *et al*., 2023; Gopi *et al*., 2016)) [16, 26] is needed for organic pest management. The lack of quality product availability, timeliness of product availability, unregulated marketing and awareness and knowledge about biological products for management of pest and disease are the constraints reported. These biological ways of pest and disease management are subjective with varying level of success and do not recommended as universal methods (Table 3). Besides that, the several of the procedure/methods/ingredients were not even tested evaluated for their successfulness.

4.5 Nutrient management

Only organic sources of animal or plant origin are allowed to use in organic farming. The total quantities of nutrient added through organic sources at present yield level are not sufficient to meet the need of crop demand on the extended area; while it should be noted that organic farming is followed on a small area of 5.19 m ha compared to total cultivated area and no any such attempt to follow organic farming principles in entire cultivated area has been suggested. Hence, this discussion of lack of organic matter to meet the need of crop nutrition is not valid. Besides that option such as green manuring and/or brown manuring have immense potential for production huge biomass with significant role in crop nutrition and able to address the concern of biomass requirement to meet the crop nutrition need in organic farming area. At present, 30.64 m t of nutrient were added through chemical fertilizers in addition of organic sources of crop nutrition and still the negative nutrient balance of 8-10 m t $year^{-1}$ was expected at present yield level (Anonymous, 2018) [2]. The different avenues for soil health management (Shahane and Shivay, 2021 and 2022) [57, 58] has significant effect on providing the nutrition to crop growth and development which are matching with the crop nutrition in organic farming. The organic products such as human excreta, sewage and sludge and city drainage water are not allowed in organic farming. The sewage and sludge are reported to have high concentration of heavy metals, bacterial contamination and having offensive smell which make it difficult to use them as a source of crop nutrition (Anonymous, 2014) [1]. The waste obtained from industrial area was also reported to have higher concentration of heavy metal pollutants which also make them unsuitable for use in organic farming systems; while the use of untreated soil minerals or waste obtained from different mineral treating plant is considered as a good source of crop nutrition in organic farming. The use of such material is constrained by presence of heavy metals, longer time taken to make nutrient available from these sources and logistic problems in case of industrial waste such as phosphogypsum, basic slag, etc.

The increasing demand and decreasing availability make the organic sources of crop nutrition costly and is well justified based on information available about high cost of cultivation organic farming than conventional farming. This can be exception for areas such as NEH where the organic matter availability is plenty due to forest cover and high soil organic carbon; while in these areas as well processing of organic manures and its availability for use is consideration. The competitive uses of organic sources of crop nutrition again reduce their availability. Time required for nutrient release and non-synchronization between crop nutrient need and nutrient release patter from organic sources of crop nutrition is another variable thing across the different types of organic manures. Besides that, processing is needed to make organic sources of crop nutrition suitable for application (For e.g. FYM, Compost, Vermi-compost, poultry manure, etc.). Therefore, demand, availability and processing is needed to address the nutritional demand of organic farming. The in-season nutrient management especially correction of deficiency symptom in growing crops) become difficult with most of the organic sources of crop nutrition. The concerns such as lack of perfect market and firm pricing policy, non-uniformity in regulation of organic nutrient sources and their production system even within a region and lack of data base of nutrient contents of different organic substances which can be useful as source of nutrition are exist and will be difficult to cure in days come due to diversity of manures. The complexity of nutrients and their varied time of nutrient release as well as wide range of sources of organic nature make it difficult to recommend and formulate the nutrient management practices. Besides that, problems of carrying hibernating stages of insect-pest and inoculums of disease causing microorganisms if the organic manure is not properly decomposed also add the consideration for use of organic sources and need processing before their use. The lack of awareness about value addition in organic sources in order to enhance their nutrient content and modify the nutrient release pattern need to be addressed for effective use of organic manure for crop nutrition. Supply of one specific nutrient is also difficult and most cases it is impossible and hence in-season nutrient deficiency correction is requiring consideration in organic production system In case of weeds, the can be used as source of nutrition; while competition during early growth stages of crops make it desirable to remove them before producing sufficient biomass and attend maturity.

Table 1: Constraints and considerations for organic farming system.

S. No.	Details of study	Constraints reported	Consideration to overcome constraints	Reference
1.	Comparison of temporal yield stability of three production system *viz*. organic, conservation and conventional through review of 193 studies and 2896 comparison.	Organic agriculture has less temporal stability (-15%) over conventional production system; while conventional system and conservation system (Zero-till) had on par in yield temporal stability.	Enhanced fertilization and application of green manures helps in reducing temporal yield gap between organic farming and conventional farming. Growing of mixture of crop species and genotypes to harvest positive interaction effects thereby reduce threat of crop failure.	Knapp and Heijden, 2018 [32]
2.	Comparison of 362 studies involving comparison of organic versus conventional agriculture study to know about the yield gap.	Organic system has yield level of 80% as that of conventional production system. This yield gap between organic and conventional production system was significantly differ for crop groups and regions.	Sufficient nutrients need to be provided in organic production system in order to reduce the yield gap. Emphasis on role of legumes in rotation and farming system as well as availability of manure at system level is needed.	De Ponti *et al*., 2012 [15]
3.	Crop yield gap and temporal stability between organic and conventional production system were studied for a 13 years old one organic and two conventional production system. Six year cropping system involving potato, pea, leek, barley, sugar beet and maize in each year followed by cover crop at Netherland were considered for study.	Yield gap and stability of yield in temporal dimensions: The yield gap between organic and conventional production system diminishes after 10-13 years. Special stability in and temporal stability in all studied production system were remain same after 13 years. Enhanced special stability in soil properties such as pH, nutrient mineralization, nutrient availability and abundance of soil biota are reasons for reducing the yield gap between organic and conventional production system; At the same time, increased nutritional provision and increased predator-based control of pest and diseases are the other reasons.	-	Schrama *et al*., 2018 [53]
4.	Technical efficiencies and yield variability across organic and conventional cotton growing farmer from West Nimar of Madhya Pradesh, India were surveyed. For both organic and conventional farming, 60 farmers each were involved (one year survey from the	Yield level of 1370 kg ha^{-1} and 1770 kg ha^{-1} was reported in organic and conventional production system, respectively; while technical efficiencies were 54.2% and 60.0%, respectively.	Awareness about potential to increase yield by using new technology, strengthening of extension services and participation of famers in technology scaling up and demonstration leading to increase in adoption rate of new technology is needed	Riar *et al*., 2020 [44]

	farmers following said production system from last three years).		to reduce the gap between technical efficiencies across the systems.	
5.	Yield, yield stability, yield resistance and maximum yield potential of tomato-maize cropping system was studied in organic, conventional and conventional practices with winter cover crop was studied after 24 years of study.	Mean yield of tomato not differ significantly among the production system; maize yield was significantly higher conventional production system than organic production system; For tomato yield stability and low risk of crop failure was found in organic production system; while for maize, conventional production system was found superior. The maximum yield potential of both tomato (91.82 Mg ha^{-1}) and maize (13.46 Mg ha^{-1}) was found in conventional system over organic system (75.18 and 9.20 Mg ha^{-1}, respectively).	-	Li *et al.*, 2019 [36]
6.	Impact of organic and inorganic amendment for nitrogen on crop yield and soil properties over 50 years (1963-2013). The cropping system was wheat-maize-wheat from 1963 to 1972, wheat-maize-sugarbeet-wheat from 1972 to 2008 and wheat-maize-mustard-wheat from 2008 to 2013. Crop residue and farm yard manure are the sources of organic manure to replace part of nitrogen supplied otherwise by mineral fertilizer sources.	The soil organic carbon and crop yield was increased by 6.2% and 3.5% in FYM applied treatment over mineral N application alone; the increase in microbial biomass C and N was 7-10% and 16-21%, respectively in residue applied and FYM applied treatments.	-	Blanchet *et al.*, 2016 [10]
7.	Yield gap between organic and conventional production system	Yield gap of 19.2 ±3.7% between organic farming and conventional farming was reported.	Multi-cropping (9±4) and crop rotation (8±5) helps in sustainable reduction in yield gap when they are applied in organic system. The yield gap varies across the management practices and crop type and is not consistent and can be reduced.	Ponisio *et al.*, 2015 [40]
8.	Study of risk and potential opportunities to reduce the risk of increasing impact of organic farming on greenhouse gas (GHG) emission for northern Europe.	Organic framing have equal or greater impact of climate change per unit product produced. The reduction in GHG emission due to reduced use of agrochemicals (fertilizers) will be counteracted by decrease in yield.	The increase in yield in organic farming with less addition of GHG emission is possible with use of catch crop or cropping system which sequester carbon in soil and standing biomass. Use of plant residue and animal residue for biogas production will have positive effect on the reducing GHG emission and also replace part of energy obtained from conventional courses emission GHG.	Roos *et al.*, 2018 [47]

Table 2: Different weed management practices in organic production system and their effect on crop yield.

S. No.	Crops/ cropping system	Organic methods of weed management	Outcomes	References
1.	Upland direct seeded rice	Studied combination of different frequency and timing of manual and mechanical (star wheel weeder) weeding in research farm and in farmer's field.	On research farm: The manual and mechanical weeding didn't differ significantly due to the use of higher seed rate, lower weed density and uniform distribution of inter and intra-row weeds. The mechanical weeding was found economical than manual weeding due to lesser labour and time requirements for weeding. In farmer field: three-time manual weeding was best due to significantly higher yield (1.74 t ha^{-1}); while mechanical weeding *fb* manual weeding will be considered economic with B:C ratio of 1.50.	Shahane and Behera, 2022 [55] and Shahane and Behera, 2023 [56]
2.	Wheat	Use of allelophatic extract of sorghum, sunflower and brassica (mustard) were applied at 25 (18 l ha^{-1}), 40 (18 l ha^{-1}) and 55 (20 l ha^{-1}) days after sowing in wheat.	The reduction in weed density and weed biomass by 48-59% and 40-58%, respectively due to application of two spray of sorghum, sunflower and brassica mustard were applied was found.	Arif *et al.*, 2015 [5]
3.	Wheat	Study the effect of mechanical weeding and combination of extract of sorghum sunflower and Raya (mustard) at 25 and 50 days after sowing at 18 l ha^{-1}.	Application of plant extract alone reduce the weed dry matter at harvest by 9.8% and 17.3% at two different locations; while weed density in reduced by 3% and 10.9% at two different locations over weedy check. The grain yield increase with application of plant extract application was 17.4% and 19.9% at two different locations over weedy check.	Kundra *et al.*, 2023 [34]
4.	Organic maize	Combination of cultural and mechanical methods of weed management	The treatment with stale seedbed preparation+hoeing once at 20 DAS+straw mulch at 5 t ha^{-1} at 30 DAS increase grain yield by 1.28 t ha^{-1}; while increase net returns by Rs. 17544 ha^{-1} over weedy check.	Jain and Maliwal, 2022 [28]
5.	Sorghum	Two intercultural operations at 20	Grain yield was increased by 0.9 and 1.07 t ha^{-1}, respectively; while weed	Priya and Kubsad,

		and 30 DAS+one hand weeding at 45 DAS were applied in sorghum for weed management and compared with weedy check.	dry matter was lower by 2.4 g m^{-2} over weedy check.	2013 [41]
6.	Sorghum	Intercropping of cowpea (1:1) in sorghum for weed management.	The sorghum plant stand of 21.5 m^{-2} was found with intercropping compared to 14.6 m^{-2} in weedy check at 60 DAS; The grain and straw yield of sorghum was increased by 870 and 3340 kg ha^{-1} with intercropping of cowpea over weedy check.	Tadasse *et al.*, 2010 [61]
7.	Maize	Study of different options of weed management in organic maize.	Soybean green manuring in-situ followed by one hand weeding reduces weed density and weedy dry matter accumulation at 60 DAS by 298 m^{-2} and 76.7 g m^{-2}, respectively. The increase in grain weight cob^{-1} is 126 g and 81 g respectively indicating significant contribution to grain yield.	Das *et al*., 2016 [14]

Table 3: Botanical and biopesticides used for management of pest and diseases in different crops.

S. No.	Crop	Practice	Results	References
1.	Cotton Pink boll worm (Bt cotton)	Use of light and sex-pheromone tarps in cotton	The sex pheromone trap found superior over light trap with 2-3 time more catching of pink boll worm. The infected bolls with plot having sex-pheromone trap were 7-9%; while in untreated plot it is 32-37%.	Arshad *et al.*, 2020 [6]
2.	Rice stem borer	Use of neem seed kernel extract (5%) at 10 days interval from 14 days after transplanted to cover tillering stage and early booting stage	The dead heart formation was significantly reduced with neem seed kernel extract application (12. 3% and 16.9% in 1st and 2nd year) over the untreated control (29.9% and 25.2%) at 80 days after transplanting. The white head formation with neem seed kernel extract application was 16.7% and 28.9% as compared to 46.1% and 42.9% with in untreated control in 1st and 2nd year of study.	Ogah *et al.*, 2011 [39]
3.	Sorghum- Major pest complex	*B. bassiana* (At dose of 2 gm witted myceliumlitter^{-1} water), *Bacillus thuringiensis* var. kurstaki (WP 9.4% at dose of 1 g l^{-1}) and *Thuja oriantalis* (0.5% leaf extract).	The reduction of *E. gayneri* due to application of *B. bassiana* was 41.38%; while the reduction in rate P. simplex was 51.64 5 with application of *Bacillus thuringiensis* var. kurstaki.	El-Gepaly *et al.*, 2021 [21]
4.	Cotton Boll worm complex (*Helicoverpa armigera* and *H. punctigera*)	Light trap and pheromone trap (male) were installed in cotton based production system (including other crops such as chickpea, sorghum, maize and sunflower) to study their effectiveness across the year in trapping the *Helicoverpa armigera* and *Helicoverpa punctigera*.	The major catch of *H. punctigera* in pheromone trap is in early spring; while *Helicoverpa armigera* were more abundant in late summer. The effectiveness of both trap and their utilization is subjective. These traps can be used for understanding the relative abundance and their timing of immigrants and locally emerging moths in cropping system in the regions.	Baker *et al.*, 2011 [7]
5.	Rice yellow stem borer	Application of different bio-pesticide for management of yellow stem borer of rice	Application of two spray of *Beauveria bassiana* (1.15% wp) showed 5.95% dean heart and white ear; while in untreated control it is 27.21%	Roopwan *et al.*, 2023 [46]
6.	Rice blast	Extract of *Piper caninum*, *Piper betle ver. Niger* and was sprayed four times at a week inter after inoculation of rice with blast (*Pyricularia oryzae* Cav.)	The percent increase in the yield due to combined application at 2% was 93.83% over untreated control; while the inhibitory activity on blast was 92.58% over untreated control.	Suriani *et al.*, 2021 [60]

5. Conclusion
The major role of nutrient management and biotic stress management in increasing crop yield, potential of alteration of these practices through different avenue and specification (restriction) in certification process were the major reason for their dominance in discussion in organic farming. The weed and water management had less significance as availability of mechanical weeding and neutral nature of water management for organic standards. The availability and use of seed and planting material for organic farming is still needed emphasis.

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Informed consent
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