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Allelopathic and organic farm products based weed management in organic agriculture

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Abstract
Organic agriculture, a holistic production system that sustains health of soils, ecosystems and people by relying on ecological processes, bio diversity and natural cycles adapted to local conditions, rather than use of inputs with adverse effects. Weed represents about 0.1% of the weed flora. The most serious threat to organic crop production is considered to weeds. Weed can suppress crop yield by competing for environmental resources such as light, moisture, nutrients and space. Fast-developing herbicide-resistant ecotypes of weeds due to increased herbicide application is another serious threat for agriculture production. Therefore, there is an urgent need to develop alternative weed control methods for use in agroecosystems. Xuan *et al.* (2005) evaluated allelopathic potential of different crops and plant parts against rice weeds and observed 25 to 91% reduction in weed population and 20 to 80% increase in rice yield due to allelochemicals present in different plants. Effective weed management on organic farms requires extensive planning and preventing measure coupled with cultural method and bio control method are the basis for successful organic farming and are necessary for breaking weed cycles. Jamshidi *et al.* (2013) conducted a study on effects of maize planting density and cowpea living mulch on weed above ground biomass (g/m^2) per species and total at harvest time and found that the use of cowpea as a living mulch had a significant effect on weed biomass. Kumari and Saini (2018) conducted a field experiment on effect of treatments on total weed dry weight and weed control efficiency in organically grown wheat at Palampur, Himachal Pradesh and reported that stale seed bed resulted into significantly lower total weed dry matter and higher weed control efficiency and among different weed management treatments, gram intercropping + one manual hoeing and two manual hoeings are statistically at par with each other that produced significantly lower weed dry weight and highest weed control efficiency over all other treatments. It is worth to focused interdisciplinary long-term research efforts should be initiated to boost the yield of crop plants by minimizing the vagaries of biotic and abiotic stresses.

Keywords: Allelopathy, *Fusarium oxysporum*, intercropping, organic agriculture, weed control efficiency

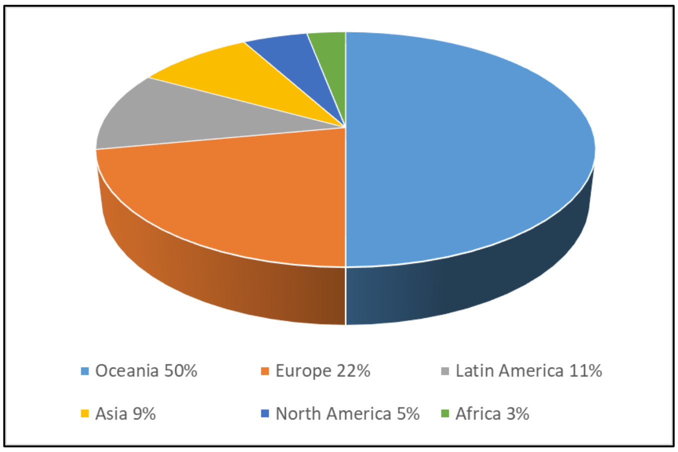
Introduction
Organic agriculture is one among the broad spectrum of production methods that are supportive of the environment. Agriculture remains the key sector for the economic development for most developing countries. It is critically important for ensuring food security, alleviating poverty and conserving the vital natural resources that the world's present and future generations will be entirely dependent upon for their survival and well-being. Green revolution technologies such as greater use of synthetic agro chemicals like fertilizers and pesticides, adoption of nutrient responsive, high-yielding varieties of crops, greater exploitation of irrigation potentials etc. has boosted the production output in most of cases. Without proper choice and continues use of these high energy inputs is leading to decline in production and productivity of various crops as well as deterioration of soil health and environments. Therefore, for sustaining healthy ecosystem, there is need for adoption of an alternatives farming system like organic farming.

The concept of organic farming was started thousand years back when ancient farmers started cultivation near the river belt depending on natural resources only. Organic farming is a production system which avoids or largely excludes the use of synthetic compounded fertilizers, pesticides, growth regulators and livestock feed additives. Organic farming refers to organically grown crops which are not exposed to any chemicals right from the stage of seed treatments to the final post-harvest handling and processing. Organic farming must sustain the health of soil, plant animal, human and planet. It relies on the four principles of health, ecology, fairness and care that combines tradition, innovation and science to benefit the shared environment and promote fair relationships and a good quality of life for all involved.

Global status of organic agriculture

The 21st survey of certified organic agriculture worldwide was carried out by the Research Institute of Organic Agriculture (*FiBL*) in collaboration with many partners from around the world. In 2018, 71.5 million hectares were under organic agricultural management worldwide. The region with the most organic agricultural land is Oceania, with 36 million hectares, followed by Europe with 15.6 million hectares, Latin America (8 million hectares), Asia (6.5 million hectares), North America (3.3 million hectares), and Africa (2.0 million hectares). Oceania has half of the global organic agricultural land. Europe, a region that has had a very constant growth of organic land over the years, has over 22% of the world's organic agricultural land followed by Latin America with 11% were depicted in Figure 1.

Australia, which continued to experience growth of its organic area in 2018, is the country with the most organic agricultural land and estimated that 97% of the farmland is extensive grazing areas. Argentina ranks second followed by China.



***Source*:** FiBL survey, 2020

Fig 1: World distribution of organic agriculture land by region 2018

India is the country with the most organic producers (1,149,371), followed by the Thailand (58,490). India possess 1.1% land of total farmland under organic cultivation and about 1.9 mha under organic agriculture (including in-conversion areas) that constitutes about 2.7% of the 71.5 mha global total in 2018. The country also constitutes 64% growth in organic acreage in decade through 2018. India is the country in the region with the largest organic wild collection area, with 1.5 million hectares, followed by China (1million hectares) and Thailand (over 117,000 hectares).

Need of organic weed management

Weed interference is one of the most important limiting factors which decrease crop yields and consequently global food production. Weed represents about 0.1% of the world flora. Weed can suppress crop yield by competing for environmental resources like water, light and nutrients and production of allelopathic compounds. Therefore, weed management have been a major challenge for crop producers from the start of agriculture. With the discovery of synthetic herbicides in the early 1930s, there was a shift in control methods toward high input and target-oriented ones. However, herbicide-reliant weed control methods can cause high costs for crop production. Fast-developing herbicide-resistant ecotypes of weeds due to increased herbicide application is another serious threat for agriculture production. Therefore, there is an urgent need to develop alternative weed control methods for use in agroecosystems. The most important alternative weed control method is use of allelopathy. Allelopathy consists of two Greek words allelon meaning each other and 'pathos' means harmful/ suffering. The term was first originated in 1937 by Prof. Hans Molish, German Botanist. Allelopathy is the direct or indirect chemical effect of one plant on the germination, growth or development of neighboring plants. Plants released secondary metabolites into the environment are known as allelochemicals, which are defense compounds pertaining to a wide range of a chemical classes, mainly phenolic compounds and terpenoids. Allelochemicalsare categorized under six classes namely alkaloids, benzoxazinones, cinnamic acid dervivates, cyanogenic compounds, ethylene and other seed germination stimulants and flavonoids. Xuan *et al.* (2005) [12] evaluated allelopathic potential of different crops and plant parts against rice weeds and observed 25 to 91% reduction in weed population and 20 to 80% increase in rice yield due to allelochemicals present in different plants. Allelochemicals occur in any plant organ (leaves, stems, roots, rhizomes, seeds, flowers, fruits, pollen) and in order to have any effect on the target plant the allelochemicals have to be released from the donor plant. This can happen in different ways:

a. Runoff and leachate from leaves and stem of plants.
b. Volatile phytotoxic compounds from the green parts of a plant, e.g. *Salvia leucophylla*
c. Phytotoxic compounds from decomposing plant material, such as rye (*Secalecereale*) when used as a mulching material.
d. Phytotoxic compounds released from the plant roots. Rice is an example, where living rice plants are able to suppress weed growth selectively (Olofsdotter *et al.*, 1997) [5].

Extract preparation of allelochemicals

Firstly, fresh plant leaves are collected and washed thoroughly with normal tap water. Then the leaves are dried under shade condition. After drying, crushed to powder form by using grinding machine and the leaf powder was stored in an air tight container. About 30 gram powdered leaf material was successively extracted with organic solvents, with increasing polarity index, like petroleum ether, chloroform, ethyl acetate and methanol using soxhlet apparatus continuously for 48 hours with 500 ml of the various solvents each and finally, left over leaf powder was boiled in distilled water for 6 hours in water bath. The extract fractions (petroleum ether extract fraction, chloroform extract fraction, ethyl acetate extract fraction, methanolic extract fraction, aqueous extract fraction) were obtained and condensed using rotary vacuum evaporator and kept for evaporation to remove solvents in hot air oven at 50 ºC till dried completely. These dried extract fractions were then stored in -20 ˚C for future use.

Approaches involved in organic weed management

A) Physical/ Mechanical weed control

Physical force either manual, animal or mechanical power is used to pull out or kill the weeds. It is both time consuming and labor- intensive but is the most effective method for managing weeds. Physical weed control aims at directly suppressing/ removing weed plants in the field to enhance the competitiveness of the crop.

In flame weeding, weed control method using brief exposure to high temperatures. Water in plant tissues rapidly expands, ruptures cells and disrupts cellular processes. Flame weeding, also called flame cultivation, relies on propane gas burners to produce a carefully controlled and directed flame that briefly passes over the weeds. Weeds are most susceptible to flaming when they are seedlings, 1 or 2 inches tall. Broadleaf weeds are more susceptible to lethal flaming than grasses. Grasses develop a protective sheath by the time they are approximately 1inch tall and may require a second flaming. Repeated flaming can likewise be used to suppress perennial weeds such as field bindweed.

B) Cultural/ Agronomic management practices

Crop rotation: Crop rotation involves alternating different crop a systematic sequence on the same land.

Cover Crops: May reduce weed emergence by 75-90%. Examples are sudan grass, buck wheat, annual rye grass

Intercropping: Growing a smother crop between rows of the main crop

Planting pattern: Crop population, spatial arrangement and the choice of cultivar.

Mulching: Allelopathic chemicals in the mulch also can physically suppress seedling emergence. Live mulch plant species that grow densely and low to the ground

C) Biological Control

The biological control of weeds involves the use of living organisms, such as insect, herbivorous fish, other animals, disease organisms, and competitive plants to limit their infestations. It is applicable to the control of only one major weed species that has spread widely. With perennial weeds the main objective of biocontrol is the destruction of the existing vegetation, in the case of annual weeds prevention of their seed production is generally more important. Some commercial myco-herbicides in use college, de-vine, biolophos and bipolaris etc.

D) Integrated Weed Management (IWM)

IWM involves use of living organisms *viz.*, insects, disease causing organisms, herbivorous fish, snails or even competitive plants for the control of weeds. It includes more than one method of control *viz.*, seed purity, crop varieties, spacing and methods of planting, cultivations, soil solarization, intercropping, crop rotation, water management, manure application, biological control and herbicides (Sanyal, 2008) [9].

On farm evaluation of various weed control practices

Jamshidi *et al.* (2013) [3] were conducted a field experiment on effects of maize planting density and cowpea living mulch on weed above ground biomass (g/m^2) per species and total at harvest time at New Zealand. The pure stand of maize that was planted at a density of 7.5 plants/m^2 had the highest weed infestation. In the absence of cowpea, increasing the maize density from 7.5 to 9 plants/m^2 reduced the total weed biomass by 21.5%. This illustrates the potential for suppressing weeds by increasing the density of maize to 16% greater than the normal planting density of 7.5 plants/m^2. The use of cowpea as a living mulch greatly affected weed growth and biomass, with the total weed biomass for a given density of maize decreasing as cowpea density increased. Averaged across the two maize densities, the biomasses of *Setariaviridis, Echinochloacrusgalli* and *Chenopodium album* and the total weed biomass were 44%, 64%, 42% and 46% lower, respectively, when cowpea was intercropped with maize at a density of 30 plants/ m^2 than in the absence of cowpea. These results showed that the use of cowpea as a living mulch had a significant effect on weed biomass.

Parameswari and Srinivas (2017) [6] observed the effect of crop establishment methods on weed density, weed dry weight and yield of rice at Hyderabad, Andhra Pradesh. In this experiment, crop establishment methods exerted significant influence on the weed count and weed dry weight, recorded at 60 DAS. They reported that total weed density recorded in transplanting (57.00/m^2) and SRI (64.48/m^2) were at par with each other and in turn were significantly lower compared to direct seeded rice (75.63) and similar trend was found with respect to total weed dry weight as presented in Table 1. The total dry weight of weeds was higher (43.49g/m^2) with direst seeded rice under puddle condition compared to transplanting (33.73 g/m^2) and SRI (37.67 g/m^2). This might be owed to failure to maintain flooded conditions in field and non-submergence of crop in initial stages, crops and weeds germinate simultaneously so competition exists. Transplanting method recorded significantly higher grain yield (4.41 t/ha) and it was at par with SRI treatment (4.27 t/ha) and both were significantly superior grain yield over DSR (3.89 t/ha). This indicates that submerged conditions in transplanted rice facilitate availability of more mineralized form of N, P and K uptake in transplanted rice than that of direct sowing which encouraged tiller production in addition to high dry matter production and grain yield.

Table 1: Effect of crop establishment methods on weed density, weed dry weight and yield of rice

Treatment	Weed density (no./m^2)	Weed dry weight (g/m^2)	Grain yield (t/ha)
SRI	8.1 (64.48)	6.2 (37.67)	4.27
Direct sown	8.8 (75.63)	6.7 (43.49)	3.89
Transplanting	7.6 (57.00)	5.9 (33.73)	4.41
LSD (P=0.05)	0.66	0.45	0.36

*Values in parenthesis () are original values

Pathak and Kannan (2011) [7] evaluated the percentage infection by different fungal pathogens on water hyacinth at Jabalpur. Pathogenicity of the pathogens were tested in one set by making an artificial wound by pricking the stem from all the four sides with a needle for facilitating the entry of the pathogen (with pin prick) and other set without the artificial pricking Pathogens when applied as a mixture caused more infection than applied alone. Maximum infection was caused by the consortia of the three pathogens *viz.*, *Fusarium oxysporum*, *Curvularia lunata* and *Alternaria alternata* in the pin prick method, causing 76% infection, while it was only 30.2% in plants without pin prick as shown in Table 2. *F. oxysporum* alone caused 68% infection with pin prick and 24.2% infection as foliar spray without pin prick. While *A. alternata* and *C. lunata* caused 48% and 40.1% infection, respectively with pin prick method and 32% and 30% infection, without pin pricking respectively. *A. alternata* has a worldwide distribution and has been isolated from almost all habitats. However, *A. alternata* and *C. lunata* are both foliar pathogens, their ability to manage the water hyacinth which produces a new flush of leaves in every week may be less when compared to the vascular pathogen *F. oxysporum* which targets the stem portion of water hyacinth. This study showedthat *F. oxysporum* may offer better advantages in the biological management of water hyacinth when compared with the other pathogens.

Table 2: The percentage infection by different fungal pathogens on water hyacinth

Treatment	Infection % (with pin prick)	Infection % (without pin prick)
Control	No infection	No infection
Curvularialunata	40.1	30.0
Alternariaalterata	48.0	32.0
Fusariumoxysporum	68.0	24.2
Consortia	76.0	30.2
LSD (P=0.05)	8.1	4.6

The study was carried out in Jordan to determine the allelopathic effect of black mustard (*Brassica nigra* L.) on germination and seedling growth of wild oat (*Avenafatua* L.) by Turk and Tawaha (2003) [11]. Allelopathic effect of extracts of different plant parts like leaf, stem, flower and root of black mustard was experimented. They found that germination and radicle length were affected by extract solutions and the inhibitory effect on germination increased with increasing concentration of extract solution of the fresh plant parts. They also observed that the protease enzyme activity was suppressed causing reduced water uptake, which led to poor seed germination of wild oat. It has been suggested that residue incorporation affected the germination, plant height and dry matter accumulation per plant and the effect was greater for both root and shoot incorporation than only root incorporation.

Boydston and Anderson (2008) [1] studied the effect of mustard seed meal on annual bluegrass and common chickweed in transplanted ornamentals at Prosser, Washington. They found that MSM inhibited emergence and reduced height and final fresh weight of annual bluegrass and common chickweed at all rates tested. All rates of MSM greatly decreased the number of annual bluegrass per container. The 225 and 450 g/m^2 rates reduced seedling numbers by 86% and 98%, respectively, and fresh weight 86% and 99%, respectively, at 8 WAT (Weeks after Transplanting) as presented in Table 3. All rates of MSM tested reduced the number of common chickweed seedlings per container and final plant weight per pot at 8 WAT. Final plant weight of common chickweed was 13% to 30% of that in non-treated checks at 8 WAT. MSM applied at 450 g/m^2 reduced final common chickweed height 53% compared with non-treated checks, whereas 113 g/m^2 reduced chickweed height only 24%.

Table 3: Effect of mustard seed meal on annual bluegrass and common chickweed in transplanted ornamentals

Mustard seed meal rate (g/m^2)	Annual bluegrass			Common chickweed		
	Number of seedlings (no./plot)	Height (cm)	Fresh weight (g/plot)	Number of seedlings (no./plot)	Height (cm)	Fresh weight (g/plot)
0	12.4	15.6	3.1	7.7	9.9	11.0
113	4.9	14.0	1.1	3.0	7.5	3.3
225	1.7	8.4	0.4	2.0	8.2	2.8
450	0.2	1.8	0.02	2.1	4.7	1.4
LSD (P=0.05)	2.7	2.9	0.8	1.7	2.1	2.8

Effect of treatments on total weed dry weight and weed control efficiency in organically grown wheat was investigated by Kumari and Saini (2018) [4] at CSKHPKV, Palampur. Stale seed bed resulted into significantly lower total weed dry weight and higher weed control efficiency compared with standard seed bed. Stale seed bed attributed lower weed biomass due to the fact that it produced suitable conditions in the field for germination of weeds that emerged and uprooted during final seed bed preparation, thus minimized weed seed bank in the soil.Among different weed management treatments, gram intercropping + one manual hoeing and two manual hoeings being statistically at par with each other produced significantly lower total weed dry weight and highest weed control efficiency over all other treatments. Intercropping decreased weed biomass due to the effective utilization of resources and weed smothering ability of the legumes due to profuse canopy resulted in higher weed control efficiency.

Shah *et al.* (2014) [10] studied the number of grains/cob and grain yield as affected by different mulches in maize crop at Islamabad and reported that data indicated that black plastic (196.6) and weeds as mulch (177.9) were the best treatments for the number of grain per cob of the maize crop as compared with weedy check plots (67.65). The grain yield was influenced by various treatments, however, remained at par to each other. In this study due to frequent rains, there was no competition for moisture and results did not differ significantly. Table 4 indicated that maximum grain was recorded from black plastic (1.91 t/ha) and weeds as mulch (1.85 t/ha). It might be due to black plastic mulches can increase soil temperature more than transparent plastic as plastic mulches are narrowly in contact with the soil, increasing the heat transmission at the mulch and soil interspaces.

Table 4: Number of grains/cob and grain yield as affected by different mulches in maize crop

Treatments	No. of grains*	Grain yield (t/ha)
Control (weedy check)	67.65 c	0.64 b
Hand weeding (HW) at 30 and 45 DAS	163.55 ab	1.59 a
Black plastic + HW 45 DAS	196.60 a	1.91 a
Transparent plastic + HW 45 DAS	150.30 ab	1.48 a
Live mulch (black gram) + HW 45 DAS	162.25 ab	1.61 a
Wheat straw (thin mulch) + HW 45 DAS	141.90 b	1.40 a
Sugarcane (thick mulch) + HW 45 DAS	155.05 ab	1.51 a
Weeds were removed by hoeing and laid in the same plot as mulch + HW	177.90 ab	1.85 a
LSD (P=0.05)	52.01	0.60

#Means followed by same letters do not differ significantly at 5% probability level.
* Average number of grain/five cobs

Saini *et al.* (2013) [8] studied the effect of various weed control treatments on yield and economics of maize organic production system at Palampur, Himachal Pradesh. They revealed that Soybean intercropping + 1 MW (20 DAS), 2 MW (20 and 40 DAS) and 2 MW (20 and 40 DAS) + mash inter-cropping being at par with each other resulted in significantlyhigher maize equivalent yield over all other treatments as depicted in Table 5. This might be due to the weed smothering ability of the legumes due to the profuse canopy which also resulted in higher weed control efficiency. Mechanical weeding (MW) at 20 DAS gave highest B:C ratio of 4.6 followed by hand weeding (HW) at 20 DAS. It was concluded that under organic farming conditions, soybean intercropping with one mechanical weeding (MW) at 20 DAS or 2 mechanical weeding at 20 and 40 DAS could be the best options for non-chemical management in maize.

Table 5: Effect of various weed control treatments on yield and economics of maize organic production system

Treatment	Maize grain equivalent yield (t/ha)	B:C ratio
Mechanical weeding (MW) at 20 DAS	3.42	4.6
Mechanical weeding (MW) at 20 and 40 DAS	3.65	2.7
Hand weeding (HW) at 20 DAS	3.25	2.9
Hand weeding (HW) at 20 and 40 DAS	3.44	1.3
Soybean intercropping (no weeding)	2.80	1.5
Soybean intercropping + 1 MW (20 DAS)	3.84	2.4
Soybean intercropping + 1 HW (20 DAS)	3.71	1.7
2 MW (20 DAS and 40 DAS) + Mash intercropping	3.82	2.1
Unweeded check	2.15	-
LSD (P=0.05)	0.24	-

Conclusion

Controlling weeds is a crucial aspect of successful crop production. It is pertinent to understand thatweeds will never be eliminated but only managed under an organic system of weed control. Allelochemicals are naturally exist in all types of plants and tissues that are released into the soil rhizosphere by a variety of mechanisms, including decomposition of residues, volatilization and root exudation. Application of herbicide and pesticide can be minimized by adopting appropriate allelopathic crops in agriculture so that will not only reduce costs in agriculture and the environmental pollution but also improve soil productivity as well as sustainability in the agroecosystem. It is worth to focused interdisciplinary long-term research efforts should be initiated to boost the yield of crop plants by minimizing the vagaries of biotic and abiotic stresses.

References

1. Boydston RA, Anderson T. Mustard (*Sinapisalba*) seed meal suppresses weeds in container-grown ornamentals. *Hort Science* 2008;43(3):800-803.
2. FiBL. 2020. https://statistics.fibl.org/
3. Jamshidi K, Yousefi AR, Oveisi M. Effect of cowpea (*Vigna unguiculata*) intercropping on weed biomass and maize (*Zea mays*) yield. New Zealand Journal of Crop and Horticultural Science 2013;41(4):180-188.
4. Kumari P, Saini JP. Weed management in organically grown wheat under mid-hill conditions of north-west Himalayas. Journal of Pharmacognosy and Phytochemistry 2018;7(3):1912-1915.
5. Olofsdotter M, Navarez D, Rebulanan M. Rice allelopathy - where are we and how far can we get? Brighton Crop Protection Conference Weeds 1997;1:99-104.
6. Parameswari YS, Srinivas A. Productivity and Economics of Rice as Influenced by Different Crop Establishment Methods and Weed Management Practices. International Journal of Current Microbiology and Applied Sciences 2017;6(6):87-94.
7. Pathak A, Kannan C. Isolation and pathogenicity of some native fungal pathogens for the biological management of water hyacinth. Indian Journal of Weed Science 2011;43(3, 4):178-180.
8. Saini JP, Rameshwar, Punam, Chadha S, Sharma S, Bhardwaj N, Rana N. Non-chemical methods of weed management in maize under organic production system. Indian Journal of Weed Science 2013;45(3):198-200.
9. Sanyal D. Introduction to the integrated weed management revisited symposium. Weed Science 2008;56:140.
10. Shah FU, Sajid GM, Siddiqui SU. Evaluation of mulching materials as integrated weed management component in maize crop. Pakistan Journal of Agricultural Research 2014;27(2):118-128.
11. Turk MA, Tawaha AM. Allelopathic effect of black mustard (*Brassica nigra* L.) on germination and growth of wild oat (*Avenafatua* L.). *Crop Prot*ection 2003;22:673-677.
12. Xuan TD, Shinkichi T, Khanh TD, Chung IM. Biological control of weeds and plant pathogens in paddy rice by exploiting plant allelopathy: an overview. Crop Protection 2005;24(3):197-206.