CAREER POINT
INTERNATIONAL JOURNAL OF RESEARCH

CPIJR

ISSN: 2583-1895

A Multidisciplinary Quarterly Peer Reviewed & Refereed Research Journal

Vol-3, Issue-3, July-Sept 2024

For more details, Call: 86190-97419, 94144-23146

www.cpijr.com | editor@cpijr.com

CAREER POINT UNIVERSITY, KOTA

Alaniya, Jhalawar Road, Kota (Rajasthan)

www.cpur.in | info@cpuniverse.in

Career Point International Journal of Research(CPIJR)
©2022 CPIJR | Volume 3 | Issue 3 | ISSN : 2583-1895
July-September 2024

CONTENTS

Career Point International Journal of Research (CPIJR)
©2022 CPIJR | Volume 3 | Issue 3 | ISSN: 2583-1895
July-September-2024 | DOI: https://doi.org/10.5281/zenodo.14029517

Organic Farming for Sustainable Agriculture in Northern India

Rohitashv Nagar[1], P. C. Choudhary[2], Dr. Narendra Kumar Bhinda[3], Deepak Nagar[4]

School of Agricultural Sciences, Career Point University, Kota

[1,2,3,4] Assistant Professor, Department of Agronomy, School of Agricultural Sciences, Career Point University, Kota, Rajasthan, India Email: rohitashv.nagar@cpur.edu.in

Abstract:

Since India's independence, one of the most critical challenges has been producing enough food to meet the demands of its growing population. This led to the widespread use of high-yielding crop varieties, supported by irrigation, fertilizers, and pesticides. While this high-yield production technology has helped India achieve a food surplus, it has also raised concerns about soil health, environmental pollution, pesticide toxicity, and the long-term sustainability of agriculture. As a result, scientists and policymakers are now revaluating agricultural practices, focusing more on biological inputs instead of the heavy reliance on chemical fertilizers and pesticides. Organic farming offers a way to produce high-quality food without harming soil health or the environment. However, there are concerns about whether large-scale organic farming can produce enough to feed India's vast population. India currently produces a variety of certified organic products, including basmati rice, pulses, honey, tea, spices, coffee, oilseeds, fruits, cereals, herbal medicines, and their value-added derivatives. In addition, non-edible organic products such as cotton, garments, cosmetics, functional foods, and body care products are also produced. The review of organic crop and product production focuses on sustainable agriculture in northern India.

Key Words: Organic Farming, Sustainable Agriculture, Northern India.

1. Introduction

The origins of the organic movement in India trace back to the work of Sir Albert Howard (1), who formulated many of the principles later embraced by those active in this movement. Organic farming is a production system that avoids or significantly reduces the use of synthetic fertilizers, pesticides, growth regulators, and livestock feed additives. It is rooted in the goals of environmental, social, and economic sustainability (2). Key practices of organic farming include maintaining long-term soil fertility through preserving organic matter, promoting biological activity in the soil, and minimizing mechanical interventions. Nitrogen self-sufficiency is achieved through the use of legumes and biological nitrogen fixation, while crop residues, livestock waste, and organic materials are effectively

Career Point International Journal of Research (CPIJR)
©2022 CPIJR | Volume 3 | Issue 3 | ISSN: 2583-1895
July-September-2024 | DOI: https://doi.org/10.5281/zenodo.14029517

recycled. Weed, disease, and pest control are managed primarily through crop rotation, natural predators, biodiversity, organic manures, and resistant crop varieties.

A strong emphasis is placed on maintaining soil fertility by returning organic waste, particularly through composting, to close the gap between the addition and removal of nutrients like nitrogen, phosphorus, and potassium (NPK) (3). However, growing population pressures have pushed many countries to rely heavily on chemical fertilizers and pesticides to increase farm productivity and meet rising food demands. Prolonged use of these chemicals has led to human health risks, soil degradation, and environmental pollution. Consequently, farmers in developed countries are being encouraged to transition to organic farming.

Consumer demand for organic food is primarily driven by health awareness and a willingness to pay a premium for high-quality produce. Organic consumers are typically affluent, educated, and health-conscious, motivated by environmental concerns and the perceived health benefits of organic products. This rising demand, along with price premiums and environmental considerations, has led many conventional growers to adopt organic farming practices. In Europe, government policies are actively supporting the organic sector through subsidies, consumer education, and initiatives in research, education, and marketing.

India's agricultural traditions date back more than 4,000 years, and organic farming is deeply rooted in the country’s history. As referenced in the Arthashastra, farmers during the Vedic period had a good understanding of soil fertility, seed selection, plant protection, crop rotation, and sustainable agricultural practices (4). Ancient Indian farmers followed natural laws, which helped them maintain soil fertility over extended periods (5).

2. Organic Sources of Plant Nutrients

At present, most optimistic estimates show that about 25–30 percent of nutrient needs of Indian agriculture can be met by various organic sources. Supplementation of entire N through FYM sustains crop productivity at more than use of conventional N fertilizers. Since the estimates of NPK availability from organic sources are based on total nutrient content, efficiency of these sources to meet the nutrient requirement of crops is not as assured as mineral fertilizers, but the joint use of chemical fertilizers along with various organic sources is capable of sustaining higher crop productivity, improving soil quality, and productivity on long-term basis [3]. These organic sources besides supplying N, P, and K also make unavailable sources of elemental nitrogen, bound phosphates, micronutrients, and decomposed plant residues into an available form to facilitate the plants to absorb the nutrients. Application of organic sources encouraged the growth and activity of mycorrhizae and other beneficial organisms in the soil and is also helpful in alleviating the increasing incidence or deficiency of secondary and micronutrients and is capable of sustaining high crop productivity and soil health [6]. The farmers can in turn, get good remuneration from organically produced crops and if included in high value crop rotations, that is, aromatic rice (*Oryza sativa* L.), table pea (*Pisum sativum* L.), and onion (*Allium cepa* L.) [7] Due to their heavy demands in domestic, national, and international markets. Nutrient concentrations in FYM are usually small and vary greatly depending upon source, conditions, and duration of storage. The N, P, and K contents of fresh FYM range widely from 0.01 to 1.9 percent on dry weight basis due to variable nature of manure production and storage [8, 9]. Tandon [10] reported that on an average, well-rotted FYM contains 0.5 per cent N, 0.2 per cent P_2O_5, and 0.5 per cent K_2O. Gaur [11] stated that an application of 25 t ha^{-1} of well-rotted FYM can add 112 kg N, 56 kg P_2O_5, and 112 kg K_2O ha^{-1}. Several researchers all over the world have shown various benefits of the application of FYM on soil properties and productivity of crops [12]. Farmers generally use straw of the harvested crop as animal feed or bedding. In most cases, straw is used as bedding to trap urine to increase N cycling. Wet straw and manures from the animal sheds are collected every day and stored or composted on the farmer's premises. The composted manure is applied either immediately or stored until the next crop season depending upon farmer's socioeconomic conditions. In particular, soil, water, and nutrient management strategies, such as reduced tillage and use of raised beds, that avoid the deleterious effects of puddling on soil structure and fertility, improve water- and nutrient-use efficiencies, and increase crop productivity, may be appropriate [13].

3. Effect of Organic Nutrition on Crop Productivity

Addition of organic matter in the soil is a well-known practice to increase crop yields. Sharma and Mitra [14] reported that the application of organic materials increased grain and straw yield of rice. Ranganathan and Selvaseelan [15] found that application of spent mushroom and rice straw compost though comparable with FYM increased rice grain yields by 20 per cent over NPK fertilizer. Singh *et al.* [16] reported that the application of 7.5 t FYM ha^{-1} produced significantly more grain, and straw yields over unfertilized fields. The entire yield attributing characters of rice increased with increasing rates of FYM. Organic farming with dhaincha (*Sesbania aculeata* L.) made considerable improvement in grain yield of rice and Chickpea [17, 18]. Stockdale *et al.* [2] narrated the benefits of organic farming to developed nations (environmental protection, biodiversity enhancement, and reduced energy use and CO_2 emissions) and to developing countries (sustainable resources use, increased crop yield without over reliance on costly inputs, and environmental and biodiversity protection). Many researchers reported that in an organically managed field activity of earth worm is higher than in inorganic agriculture [19]. In the biodegradation process earthworms and microbes work together and produce vermicompost, which is the worm fecal matter with worm casts. Vermicompost provided macro-elements such as N, P, K, Ca, and Mg and microelements such as Fe, Mo, Zn, and Cu [20]. The vermicompost contained 0.74, 0.97, and 0.45 per cent nitrogen, phosphorus, and potassium, respectively [21]. In low-input agriculture, the crop productivity under organic farming is comparable to that under conventional farming. Tamaki *et al.* [22] reported that the growth of rice was better under continuous organic farming than with conventional farming. Agro-economic study of practices of growing maize with compost and liquid manure top dressing in low-potential areas showed significantly better performance than those of current conventional farmer practices of a combined application of manure and mineral fertilizers. Maize grain yields were 11–17 per cent higher than those obtained with conventional practices [23]. Productivity of the crop during the initial year in an organically managed field is lower than in subsequent years as soil fertility levels increase over time as organic materials are added in the organic management system [24]. Similarly, Surekha [25] revealed that a gradual increase in grain yield with the use of organic fertilizers over a period of time was observed. Chan *et al.* [26] showed that the input of organic rice production in three different regions was 46, 25, and 22 per cent higher than conventional rice production, but rice yield was only 55, 94, and 82 per cent of conventional rice production, respectively. However, the cost of lower yield with higher inputs is compensated by the higher premium prices of organically crops in the markets [26]. Vegetables are highly responsive to organic sources of nutrients and profitable to farmers. Kalembasa [27] reported that vermicompost application of 15 kg per square meter gave the highest yield in tomato crop. Singh *et al.* [28] studiedthe response of chilli (*Capsicum annuum* L.) to vermicompost and observed that the application of vermicompost increased the microbial activities. Vermicompost has a positive effect on the performance of crops due to a higher number of branches and fruits [28]. Tomar *et al.* [29] recorded the highest yield (97 g plant^{-1}) through vermicompost in brinjal (*Solanum melongena* L.). Kalembasa and Deska [30] obtained significantly higher yield of sweet pepper (*Capsicum annum* L. var. grossum) with vermicompost. Reddy *et al.* [31] recorded maximum plant height at harvest, days to first flowering, and branches plant^{-1} with the application of vermicompost (10 t ha^{-1}). Similarly, Tomar *et al.* [29] reported that the application of vermicompost significantly increased leaf area in carrot (Daucus carota L.) plants. Manjarrez *et al.* [32] conducted an experiment on chili receiving 1.25, 2.0, 3.0, 4.0, 6.0, or 10.0 g of vermicompost kg^{-1} of soil under greenhouse conditions and reported that the foliar area and photosynthetic rate rose with increasing vermicompost application, and the highest photosynthetic rate (12 μ mol CO_2 m−2 s $^{-1}$) was observed with vermicompost at 10 g kg^{-1} soil. Atiyeh *et al.* [33] observed that when 20 per cent commercial horticultural medium was replaced by vermicompost there was significant increase in plant height and root and shoot biomass in tomato crop. Ribeiro *et al.* [34] observed that dry matter content increased with increasing the vermicompost dose up to 400 g kg^{-1}soil in sweet pepper cv. Nacional Ag. 506. Atiyeh *et al.* [33] conducted an experiment in which tomatoes were grown in a standard commercial greenhouse container medium (Metro-Mix 360, Manufacturer: Sun Gro Horticulture Canada Ltd., 770 Silver Street Agawam, MA, USA, 01001), considered as control, substituted with 10, 20, 30, 40, 50, 60, 70, 80, 90, and 100 per cent (by volume) pig (*Sus scrofa* L.) manure vermicompost. They obtained highest marketable yield (5.1 kg per plant) with substitution of Metro-Mix 360 with 20 per cent vermicompost. Substitution of Metro-Mix 360 with 10, 20, and 40 per cent vermicompost reduced the proportion of fruit that were nonmarketable and produced more large size (diameter > 6.4 cm) than small size (diameter < 5.8 cm) fruits. Shreeniwas *et al.* [35] conducted a field experiment on ridge gourd (*Luffa acutangula* L. Roxb.) and observed that the increasing levels of vermicompost (0, 5, 10, and 15 t ha^{-1}) increased the fruit weight and fruit volume. Rao and Sankar [36] observed that the effect of organic manure on leaf number, leaf area index, dry matter production, and other growth characters was significantly better than those of inorganic fertilizer in brinjal. Samawat *et al.* [37] reported that vermicompost had a significant effect on root and fruit weight of tomatoes. In 100 percent vermicompost treatment, fruit, shoot, and root weights were three, five, and nine times, respectively more than control. Where vermicompost was applied at at 5 t ha^{-1} or at 10 t ha^{-1}, increased shoot weight and leaf area of pepper plants (*Capsicum annuum* L.) compared to inorganic fertilizers [38]. Choudhary *et al.* [39] obtained the highest yield and available N of tomato cv. S-22 and cabbage (*Brassica oleracea* L.var. capitata) cv. Golden Acre with vermicompost at 200 g/plant + FYM at 250 g/plant, while maximum K and soil organic carbon was obtained with vermicompost at the rate of 100 g $plant^{-1}$ + FYM at 500 g $plant^{-1}$. Hashemimajd *et al.* [40] revealed that the treatment vermicompost produced from raw dairy manure (RDM) along with some other compost (sewage sludge + rice hull) assimilated higher shoot and root dry matter (DM) of tomatoes than the control (soil + sand). Patil *et al.* [41] reported that total potato (*Solanum tuberosum* L.) tubers yield was significantly higher with the application of vermicompost at 4 t ha^{-1} and FYM at 25 t ha^{-1}. Sawicka *et al.* [42] reported that the cultivation system had the strongest effect on the share of commercial potato tubers and tubers of a diameter of 4–6 cm in the total yield. Haase *et al.* [43] suggested that tubers from organic potato cropping may be expected to have sufficiently high tuber dry matter concentrations (19%) for processing into French fries without impairing the texture of the fries when concentration exceeds 23%. Dry matter concentration of tubers for crisps (cv. Marlen) fell short of the required minimum of 22% when a combined N and K fertilizer was applied. Mourao *et al.* [44] found that organically grown potato cv. Virgo yielded 66% of the conventional crop, whereas Raja yielded 46.6%. The nitrogen uptake of organic crop (tubers and foliage) was 37.0 kg/ha for Raja and 50.5 kg/ha for Virgo compared to that of 21.1% and 27.8% of nitrogen uptake, respectively, with mineral fertilizer. Addition of organic amendments and casting of earthworms to soil also proved effective in controlling diseases in pea (*Pisum sativum* L.), mustard (*Brassica juncea* L. Coss.), and chickpea (*Cicer arietinum* L.) during winter season. Nitrogen, phosphorus, potassium, calcium, and magnesium accumulation also increased with increasing doses of vermicompost as well as with fertilizers [45]. Singh [46] observed that the application of vermicompost at 13– 20 q ha^{-1} increased yield of pea (23.62 q ha^{-1}) and groundnut (*Arachis hypogaea* L.) (12.16 q ha^{-1}). The principal findings of Jat and Ahlawat [47] revealed that the application of 3 t vermicompost ha^{-1} to chickpea improved dry matter accumulation, grain yield, and grain protein content in chickpea, soil nitrogen and phosphorus and bacterial count, dry fodder yield of succeeding maize (*Zea mays* L.), and total nitrogen and phosphorus uptake by the cropping system over no vermicompost. Baswana and Rana [48] reported that the highest pod yield (93.96 q/ha) of pea was recorded when farm yard manure (1 t ha^{-1}) + poultry manure (1 t ha^{-1}) along with mulch treatment was applied followed by farm yard manure (2 t ha^{-1}) + biofertilizers with mulch treatment. Similar trend was also observed for biological yield and harvest index. Dayal and Agarwal [49] observed that the seed yield of sunflower (Helianthus annus L.) was increased with the higher rate of vermicompost (10 t ha^{-1}); the best combination was 5 t ha^{-1} vermicompost. Somasundaram *et al.* [50] reported that the study revealed that increased soluble protein content and nitrogenase activity of maize, sunflower, and green gram (*Vigna radiata* L.) was estimated with biogas slurry. Increased nitrogen accumulation at all growth stages on maize, sunflower, and green gram was observed under biogas slurry with panchagavya. Higher yield of maize and sunflower was recorded under biogas slurry with panchagavya (a preparation of 5 cow products (dung, urine, milk, ghee and curds)). Silwana *et al.* [51] reported the importance of organic manure and its long time usefulness in increasing productivity of maize-bean (*Phaseolus vulgaris* L.) intercrop for small-scale farmers in Eastern Cape of South Africa. Sangakkara *et al.* [52] found that the organic matter incorporation increased soil water retention in soil and hence enhanced root growth, culminating in high yields of maize. The impact was greater in maize than in cowpea, especially with gliricidia leaves. Seo and Lee [53] reported that soil organic nitrogen increased considerably by hairy vetch. Dry matter yields of maize increased more in hairy vetch than ammonium nitrate with N rates over 160 kg ha^{-1}. Adiku*et al.* [54] revealed that the fertilized maize-grass and maize-pigeon pea (*Cajanus cajan* L. Millspaugh) rotations were identified as those that sustained relatively high maize yields, returned large residue amounts to the soil, and minimized soil carbon loss. Oliveira *et al.* [55] reported that the highest average head weight (700 g) and yield (38 t ha^{-1}) in cabbage cv. Matsukaze was produced with the application of earthworm compost at 27 and 29 t ha^{-1}, respectively. Datta *et al.* [56] confined that the inoculation of seed with *Rhizobium leguminosarum* bv. phaseoli and incorporation of FYM one week before sowing of rajmash (*Phaseolus vulgaris* L.) increased yield. Similarly, inoculation of seed enhanced N fixation and incorporation of FYM left a net positive balance of 42 and 84 kg N, respectively, with regards to control (no seed inoculation and no FYM incorporation in soil). A higher accumulation rate of available N at all the growth stage of rajmash was observed with incorporation of FYM and inoculation of seed over control (no seed inoculation and no FYM incorporation in soil). In all four of the years studied, the organic and conventional farming systems did not show significant differences in marketable yields for any vegetable crops, namely, tomato, bean, cabbage, and zucchini (*Cucurbita pepo* L.).The yields in organic farming were 10 per cent and 3 per cent, respectively, higher than conventional farming [57]. Sarangthem and Salam [58] reported that the application of decomposed urban waste with total nitrogen 0.58– 1.9 per cent, available phosphorus 0.45–0.67 per cent, and

Career Point International Journal of Research (CPIJR)
©2022 CPIJR | Volume 3 | Issue 3 | ISSN: 2583-1895
July-September-2024 | DOI: https://doi.org/10.5281/zenodo.14029517

available potash 1.4–1.8 per cent increased the yield of bean to 228 gm/pot from 53 gm/pot. The response on growth and yield of bean (228 g/pot) was recorded higher in the decomposed manure enrich with vermiculture. Renuka and Sankar [59] reported in tomato that the yield increased two and half times with the application of organic manures in comparison with inorganic fertilizer (18.44 tonnes). Likewise, Samawat *et al.* [37] reported that vermicompost had a significant effect on the number of fruits in tomato. In 100 per cent vermicompost treatment, fruit numbers were four times more than the control treatment. Arancon *et al.* [38] reported that when vermicompost applied at 5 t ha^{-1} or 10 t ha^{-1}, the marketable tomato yield in all vermicompost treated plots were considerably greater than yield from the inorganic fertilizer plots. The total and marketable fruit yield of pepper also increased with vermicompost compared with inorganic fertilizers. Thanunathan *et al.* [60] reported that soil + mine spoil + coir pith vermicompost (1 : 1 : 1) significantly increased plant height, number of leaf, and root length in onion (Allium cepa L.). Lopes *et al.* [61] reported that the application of vermicompost at 10 t ha^{-1} significantly increased nodulation and dry matter yield of cowpea (*Vigna sinensis* L.) over its lower levels, namely, 0 and 5 t ha^{-1}.

4. Effect of Organic Nutrition on Quality Parameters of Crops

Yadav and Vijayakumari [62] carried out an experiment to assess the effect of vermicompost vegetable waste on the biochemical characters of chilli and found that the protein was higher at 60 (113 mg g^{-1}) and 90 DAS (79 mg g^{-1}). The carbohydrate content was higher in vermicompost treatment at 60 DAS (15.34 mg g^{-1}). Chlorophyll (2.61 mg g^{-1}) and total chlorophyll (3.62 mg g^{-1}) contents were observed at 60 DAS, while chlorophyll a (1.01 mg g^{-1}) was higher at 90 DAS as compared to inorganic fertilizers. In another experiment, Haase *et al.* [43] suggested that tubers from organic potato cropping may be expected to have sufficiently high tuber dry matter concentrations (19 per cent) for processing into French fries without impairing the texture of the fries when concentrations exceed 23 per cent. Similarly, application of FYM at 10 t ha^{-1} alone increased the economic yield and quality parameters like hulling percentage, milling percentage, and protein and amylose content of rice cv. Saket4 [63]. Mourao *et al*. [44] found that organically grown potato Virgo yielded 66 per cent of the conventional crop, whereas Raja yielded 47 per cent. The nitrogen uptake of organic crop (tubers and foliage) was 37.0 kg/ha for Raja and 50.5 kg/ha for Virgo, respectively, 21 and 28 per cent of nitrogen uptake by same cultivars grown with mineral fertilizer. Although foliage nitrogen content was increased for the conventional crops, difference between N content of organic and conventional tubers were not significant, as well as for K, Ca, and Mg. Maheswari *et al.* [64] studied the effect of foliar organic fertilizers on the quality and economics of chilli and observed the highest ascorbic acid content (175.23 mg/100 g) with vermiwash : water at 1 : 5 ratio.

5. Effect of Organic Nutrition on Soil Fertility

Minhas and Sood [65] also reported that the organic matter after decomposition release macro- and micronutrients to the soil solution, which becomes available to the plants, resulting in higher uptake. Organic farming was capable of sustaining higher crop productivity and improving soil quality and productivity by manipulating the soil properties on long term basis. It was reported that organic and low-input farming practices after 4 years led to an increase in the organic carbon, soluble phosphorus, exchangeable potassium, and pH and also the reserve pool of stored nutrients and maintained relativity stable EC level [66, 67]. Normal composting takes a long time leading to considerable loss of organic materials as CO_2 or does not contribute to the organic pool [68]. Bulluck *et al*. [69] reported thathe use of compost raised soil pH from 6.0 without compost to 6.5 with compost and reduced the broadleaf weed population by 29 per cent and grassy weed population by 78 per cent. Degradation of soil organic matter reduced nutrient supplying capacity, especially, on soils with high initial soil organic matter content in rice-wheat cropping system [70]. Organic farming improved organic matter content and labile status of nutrients [71] and also soil physicochemical properties. Addition of carbonaceous materials such as straw, wood, bark, sawdust, or corn cobs helped the composting characteristics of manure. These materials reduced water content and raised the C: N ratio. However, under Indian conditions, joint composting of the manure slurries with plant residues was more viable and profitable than its separate composting. Use of FYM and green manure maintained high levels of Zn, Fe, Cu, and Mn in rice-wheat rotation [72]. Laxminarayana and Patiram [73] concluded that the decline in soil reaction might be due to organic compounds added to the soil in the form of green as well as root biomass which produced more humus and organic acids on decomposition. Urkurkar *et al.* [74] reported that supply of 100 per cent nitrogen, that is, 120 kg/ha for rice and 150 kg/ha for potato in a rice-potato cropping system 1/3 each from cow dung manure, neem cake, and composed crop residue appreciably increased the organic carbon (6.3 g kg^{-1}) over initial value (5.8 g kg^{-1}) as compared to supply from inorganic fertilizers alone. However, availability of phosphorus and potassium did not show any perceptible change after completion of five cropping cycles under organic as well as integrated nutrient approaches.

6. Impact of Organic Nutrition on Soil Biological Properties

Compost contains a variety of microorganisms, including bacteria, actinomycetes, and fungi. When compost is added to soil, it not only introduces these microorganisms but also stimulates their activity (75, 76). Additionally, compost plays a key role in controlling plant nematodes and mitigating the effects of pesticides through a process called sorption. Sorption, a critical interaction between soil organic matter and pesticides, limits both the degradation and transport of pesticides in the soil. Pesticides that bind to soil organic matter or clay particles become less mobile and bioavailable, but they are also less accessible for microbial degradation, making them more persistent (77–79).

Composting materials provide an abundance of carbon, increasing the populations of heterotrophic bacteria and fungi, which enhances the activity of soil enzymes responsible for converting nutrients into forms that plants can utilize. For example, the application of farmyard manure (FYM) along with rhizobium, or co-inoculation of phosphate solubilizing bacteria (PSB) with rhizobium, has been shown to increase soybean (Glycine max L. Merr.) production (80). Agricultural practices significantly affect soil's biological and physicochemical properties, with studies showing that bacteria, protozoa, nematodes, and arthropods are more abundant in soils under organic farming compared to conventional farming (81). Research by Bulluck et al. (82) indicated that organic fertility amendments enhance beneficial soil microorganisms, reduce pathogen populations, increase total carbon, improve cation exchange capacity, and lower soil bulk density, thereby improving overall soil quality. The National Academy of Agricultural Sciences (NAAS) has recommended a holistic approach for India that includes integrated nutrient management (INM) and integrated pest management (IPM) to enhance input efficiency, while promoting region-specific cropping systems as part of an organic farming strategy. They suggest beginning with high-value crops such as spices, medicinal plants, fruits, and vegetables (83).

Singh and Bohra (84) reported that a rice-pea-black gram (Vigna mungo L.) cropping system supported a higher population of bacteria, actinomycetes, and fungi than a rice-wheat system. Field experiments with phosphate solubilizing microorganisms (PSMs) like Aspergillus awamori, Pseudomonas striata, and Bacillus polymyxa significantly increased yields in wheat, rice, and cowpea (Vigna sinensis L.), while reducing the need for phosphate fertilizer by 30 kg P_2O_5 ha^{-1}. Vegetable crops also responded positively to Azotobacter inoculation, and yield increases of 0-31% were observed in crops like wheat, maize, sorghum (Sorghum bicolor L. Moench), cotton (Gossypium spp.), and mustard (85).

In low-input agriculture, crop productivity under organic farming can be comparable to conventional farming. For instance, the integrated use of rice straw compost with Azotobacter and PSB showed better results than using rice straw alone (86). Azotobacter produces growth-promoting substances that improve seed germination and root system development. It also produces polysaccharides that enhance soil aggregation (87). Seed inoculation of chickpea with rhizobium and PSB increased dry matter accumulation, grain yield, grain protein content, and overall nitrogen and phosphorus uptake by the cropping system, outperforming treatments with rhizobium alone.

7. Conclusion

Organic farming can provide quality food without adversely affecting the soil’s health and the environment. There is need to identify suitable crops/products on regional basis for organic production that has international market demands. The whole region as such cannot afford to go for organic at a time because of its commitments to insure food and nutritional security. This will provide ample opportunity for employment and bring prosperity and peace in the region.

References

[1] A. Howard, An Agricultural Testaments, Oxford University Press, 1940.

[2] E. A. Stockdale, N. H. Lampkin, M. Hovi*et al.*, “Agronomic and environmental implications of organic farming systems,” Advances in Agronomy, vol. 70, pp. 261–327, 2001

[3] P. K. Chhonkar, “Organic farming myth and reality,” in Proceedings of the FAI Seminar on Fertilizer and Agriculture Meeting the Challenges, New Delhi, India, December 2002.

[4] P. K. Sofia, R. Prasad, and V. K. Vijay, “Organic farmingtradition reinvented,” Indian Journal of Traditional Knowledge, vol. 5, no. 1, pp. 139–142, 2006.

[5] S. Chandra and S. K. Chauhan, “Prospects of organic farming in India,” Indian Farming, vol. 52, no. 2, pp. 11–14, 2004.

[6] K. K. M. Nambiar, P. N. Soni, M. R. Vats, D. K. Sehgal, and D. K. Mehta, “AICRP on long term fertilizer experiments,” Annual Reports 1987-88 and 1988-89, IARI, New Delhi, India, 1992.

[7] S. Kalyan, “Development of sustainable farming system model for the Irrigated agro-ecosystem of Eastern UP, ICAR, Adhoc project,” Final Annual Report, Department of Agronomy, Institute of Agricultural Science, Banaras Hindu University, Varanasi, India, 2005.

[8] A. Inoko, “Compost as source of plant nutrients,” in Organic Matter and Rice, S. Banta and C. V. Mendoza, Eds., pp. 137–146, IRRI, Los Banos, Philippines, 1984.

[9] Z. I. Zhu, C. Q. Liu, and B. F. Jiang, “Mineralization of organic nitrogen, phosphorus and sulphur in some paddy soils in China,” in Organic Matter and Rice, pp. 259–272, IRRI, Los Banos, Philippines, 1984.

[10] H. L. S. Tandon, “Fertilizers and their integration and organics and bio-fertilizers,” in Fertilizers, Organic Manures, Recyclable Wastes and Bio-Fertilizers, H. L. S. Tandon, Ed., pp. 32–36, FDCO, New Delhi, India, 1992.

[11] A. C. Gaur, “Bulky organic manures and crop residues,” in Fertilizer Organic Manures RecyclableWastes and Bio-Fertilizers, H. L. S Tandon, Ed., Fertiliser Development and Consultation Organisation, New Delhi, India, 1992.

[12] R. T. Prabhakar, M. Umadevi, and R. P. Chandrasekhar, “Effect of fly ash and farm yard manure on soil properties and yield of rice grown on an inceptisol,” Agricultural Science Digest, vol. 30, no. 4, pp. 281–285, 2010.

[13] J. Timsina and D. J. Connor, "Productivity and management of rice-wheat cropping systems: issues and challenges," Field Crops Research, vol. 69, no. 2, pp. 93–132, 2001.

[14] A. R. Sharma and B. N. Mitra, "Complementary effect of organic material in rice-wheat crop sequence," The Indian Journal of Agricultural Sciences, vol. 60, no. 3, pp. 163–168, 1990.

[15] D. S. Ranganathan and D. A. Selvaseelan, "Mushroom spent rice straw compost and composted coir pith as organic manures for rice," Journal of the Indian Society of Soil Science, vol. 45, no. 3, pp. 510–514, 1997.

[16] G. Singh, O. P. Singh, R. A. Yadava, P. P. Singh, and R. Nayak, "Response of rice (Oryza sativa) varieties to nitrogen levels in flash flood conditions," Indian Journal of Agronomy, vol. 43, no. 3, pp. 506–510, 1998.

[17] K. N. Singh, B. Prasad, and S. K. Sinha, "Effect of integrated nutrient management on a Typic Haplaquant on yield and nutrient availability in a rice-wheat cropping system," Australian Journal of Agricultural Research, vol. 52, no. 8, pp. 855– 858, 2001.

[18] K. N. Singh, I. P. Sharma, and V. C. Srivastava, "Effect on FYM fertilizer and plant density on productivity of rice-what sequence," Journal of Research, Birsa Agricultural University, vol. 13, no. 2, pp. 159–162, 2001.

[19] C. A. Edwards and J. R. Lofty, "The invertebrate fauna of the Park Grassplots. I: soil fauna," Rothamsted Report, part 2, pp. 133–154, 1974.

[20] K. Amir and I. Fouzia, "Chemical nutrient analysis of different composts (Vermicompost and Pitcompost) and their effect on the growth of a vegetative crop Pisum sativum," Asian Journal of Plant Science and Research, vol. 1, no. 1, pp. 116–130, 2011.

[21] M. Pal, Basics of Agriculture, Jain Brothers, New Delhi, India, 2002.

[22] M. Tamaki, T. Itani, and H. Nakano, "Effects of organic ad inorganic fertilizers on the growth of rice plants of rice plants under different light intensities," Japanese Journal of Crop Science, vol. 71, no. 4, pp. 439–445, 2002.

[23] D. D. Onduru, J. M. Diop, E. Van der Werf, and A. De Jager, "Participatory on-farm comparative assessment of organic and conventional farmers' practices in Kenya," Biological Agriculture and Horticulture, vol. 19, no. 4, pp. 295–314, 2002.

[24] S. K. Yadav, S. Yogeshwar, M. K. Yadav, B. Subhash, and S. Kalyan, "Effect of organic nitrogen sources on yield, nutrient uptake and soil health under rice (Oryza sativa) based cropping sequence," Indian Journal of Agricultural Sciences, vol. 83, no. 2, pp. 170–175, 2013.

Career Point International Journal of Research (CPIJR)
©2022 CPIJR | Volume 3 | Issue 3 | ISSN: 2583-1895
July-September-2024 | DOI: https://doi.org/10.5281/zenodo.14029517

[25] K. Surekha, “Nitrogen-release pattern from organic sources of different C : N ratios and lignin content, and their contribution to irrigated rice (Oryza sativa),” Indian Journal of Agronomy, vol. 52, no. 3, pp. 220–224, 2007.

[26] K. Y. Chan, C. Dorahy, T. Wells *et al.*, “Use of garden organic compost in vegetable productionunder contrasting soil P status,” Australian Journal of Agricultural Research, vol. 59, no. 4, pp. 374–382, 2008.

[27] D. Kalembasa, “The effects of vermicompost on the yield and chemical composition of tomato,” ZeszytyProblemowePostępow´ NaukRolniczych, vol. 437, pp. 249–252, 1996.

[28] J. Singh, S. S. Bhat, M. R. Sudharshan, Jasvir-Singh, and S. Sreekrishna-Bhat, “Performance of Scotch Bonnet chilli in Karnataka and its response to vermicompost,” Indian Cocoa, Arecanut& Spices Journal, vol. 21, pp. 9–10, 1997.

[29] V. K. Tomar, R. K. Bhatnagar, and R. K. Palta, “Effect of vermicompost on production of brinjal and carrot,” Bhartiya Krishi AnusandhanPatrika, vol. 13, no. 3-4, pp. 153–156, 1998.

[30] S. Kalembasa and J. Deska, “The possibility of utilizing vermicompost in the cultivation of radish and paprika,” Annals of Agricultural University of Poznan, vol. 27, pp. 131–136, 1998.

[31] R. Reddy, M. A. N. Reddy, Y. T. N. Reddy, N. S. Reddy, and M. Anjanappa, “Effect of organic and inorganic sources of NPK on growth and yield of pea,” Legume Research, vol. 21, no. 1, pp. 57–60, 1998.

[32] Manjarrez, M. J. Martinez, R. Ferrera Cerrato, and M. C. Gonzalez Chavez, “Effect of vermicompost and mycorrhizal fungi on growth and photosynthetic rate of chilli,” Terra, vol. 17, no. 1, pp. 9–15, 1999.

[33] R. M. Atiyeh, N. Arancon, C. A. Edwards, and J. D. Metzger, “Influence of earthworm-processed pig manure on the growth and yield of greenhouse tomatoes,” Bioresource Technology, vol. 75, no. 3, pp. 175–180, 2000.

[34] L. G. Ribeiro, J. C. Lopes, F. S. Martins, and S. S. Ramalho, “Effect of organic fertilizer application on sweet pepper yield,” HorticulturaBrasileira, vol. 18, pp. 134–137, 2000.

[35] C. H. Shreeniwas, S. Muralidhar, and M. S. Rao, “Yield and quality of ridge gourd fruits as influenced by different levels of inorganic fertilizers and vermicompost,” Annals of Agricultural Research, vol. 21, pp. 262–266, 2000.

[36] T. S. S. Rao and C. R. Sankar, “Effect of organic manures on growth and yield of brinjal,” South Indian Horticulture, vol. 49, pp. 288–291, 2001

[37] S. Samawat, A. Lakzian, and A. Zamirpour, "The effect of vermicompost on growth characteristics of tomato," Agricultural Science and Technology, vol. 15, no. 2, pp. 83–89, 2001.

[38] N. Q. Arancon, C. A. Edwards, P. Bierman, J. D. Metzger, S. Lee, and C. Welch, "Effects of vermicomposts on growth and marketable fruits of field-grown tomatoes, peppers and strawberries, the 7th international symposium on earthworm ecology, Cardiff, Wales, 2002," Pedobiologia, vol. 47, no. 5-6, pp. 731–735, 2003.

[39] R. S. Choudhary, A. Das, and U. S. Patnaik, "Organic farming for vegetable production using vermicompost and FYM in Kokriguda watershed of Orissa," Indian Journal of Soil Conservation, vol. 31, no. 2, pp. 203–206, 2003.

[40] K. Hashemimajd, M. Kalbasi, A. Golchin, and H. Shariatmadari, "Comparison of vermicompost and composts as potting media for growth of tomatoes," Journal of Plant Nutrition, vol. 27, no. 6, pp. 1107–1123, 2004.

[41] M. P. Patil, N. C. Hulamani, S. I. Athani, and M. G. Patil, "Response of tomato (Salanum tuberosum) cv. Kufri Chandramukhi to integrated nutrient management," Advances in Agricultural Research in India, vol. 8, pp. 135–139, 1997.

[42] B. Sawicka, P. Barbas, and J. Kus, "Variability of potato yield and its structure in organic and integrated crop production systems," Electronic Journal of Polish Agricultural Universities, vol. 10, no. 1, pp. 425–427, 2007.

[43] T. Haase, C. Schuler, N. U. Haase, and J. Heß, "Suitability of ¨ organic potatoes for industrial processing: effect of agronomical measures on selected quality parameters at harvest and after storage," Potato Research, vol. 50, no. 2, pp. 115–141, 2007.

[44] I. Mourao, L. M. Brito, and J. Coutinho, "Cultivating thefuture based-on science, volume-1: organic crop-production," in Proceedings of the 2nd Scientific Conference of the International Society of Organic Agriculture Research ISOFAR, held at the 16th IFOAM Organic World Conference in Cooperation with the International Federation of Organic Agriculture-Movements IFOAM and the ConsorzioModenaBio, pp. 596–599, International Society of Organic Agricultural Research (ISOFAR), Bonn, Germany, June 2008.

[45] S. C. Tripathi, D. S. Chauhan, R. K. Sharma, and O. P. Dhillon, "Productivity and economics of different wheat (*Triticum aestivum*) based cropping sequences," Indian Journal of Agronomy, vol. 44, no. 2, pp. 237–241, 1999.

[46] R. A. Singh, "Feasibility of vermi-farming in peanut (Arachis hypogaea)-vegetable pea (Pisum sativum) cropping system," Indian Journal of Agronomy, vol. 45, no. 2, pp. 257–262, 2000.

[47] R. S. Jat and I. P. S. Ahlawat, "Direct and residual effect of vermicompost, biofertilizers and phosphorus on soil nutrient dynamics and productivity of chickpea-fodder maize sequence," Journal of Sustainable Agriculture, vol. 28, no. 1, pp. 41–54, 2006.

[48] K. S. Baswana and M. K. Rana, "Effect of organic sources and biofertilizers on growth and yield of garden pea (Pisum sativum L)," Haryana Journal of Horticultural Sciences, vol. 36, no. 3-4, pp. 326–330, 2007.

[49] D. Dayal and S. K. Agarwal, "Response of sunflower genotypes (Helianthus annuus) to nutrient management," Indian Journal of Agricultural Sciences, vol. 69, no. 1, pp. 10–13, 1999.

[50] E. Somasundaram, M. A. Mohamed, K. Thirukkumaran, Chandrasekaran, K. Vaiyapuri, and K. Sathyamoorthi, "Biochemical changes, nitrogen flux and yield of crops due to organic sources of nutrients under maize based cropping system," Journal of Applied Sciences Research, vol. 3, pp. 1724–1729, 2007.

[51] T. T. Silwana, E. O. Lucas, and A. B. Olaniyan, "The effects of inorganic and organic fertilizers on the growth and development of component crops in maize/bean intercrop in Eastern Cape of South Africa," Journal of Food, Agriculture and Environment, vol. 5, no. 1, pp. 267–272, 2007.

[52] R. Sangakkara, P. Bandaranayake, U. Dissanayake, and J. N. Gajanayake, "Organic matter addition in organic farming— impact on root development and yields in maize and cowpea over dry seasons," in Proceedings of the 2nd Scientific Conference of the International Society of Organic Agriculture Research (ISOFAR '08), held at the16th IFOAM Organic World Conference in Cooperation with the International Federation of OrganicAgriculture Movements IFOAM and the ConsorzioModenaBio, Modena, Italy, June 2008.

[53] J. Seo and H. J. Lee, "Mineral nitrogen effects of hairy vetch (Vicia villosa Roth) on maize (Zea mays L.) by green manure amounts," Journal of Agronomy, vol. 7, no. 3, pp. 272–276, 2008.

[54] S. G. K. Adiku, J. W. Jones, F. K. Kumaga, and A. Tonyigah, "Effects of crop rotation and fallow residue management on maize growth, yield and soil carbon in a savannah-forest transition zone of Ghana," Journal of Agricultural Science, vol. 147, no. 3, pp. 313–322, 2009.

[55] A. P. Oliveira, D. S. Ferreira, C. C. Casta, A. F. Silva, and E. V. Alves, "Utilization of cattle manure and earthworm compost in hybrid cabbage production," Horticulture Brasileira, vol. 13, pp. 70–73, 2001.

[56] N. Datta, M. C. Rana, and R. P. Sharma, "Effect of seed inoculation and farm yard manuring on nitrogen balance and yield in Rajmash (Phaseolus vulgaris)," Indian Journal of Plant Physiology, vol. 11, no. 1, pp. 108–112, 2006.

[57] V. Tabaglio, C. Gavzzi, and G. Nervo, "Cultivating the future based on science. Volume 1: organic crop production," in Proceedings of the 2nd Scientific Conference of the International Society of Organic Agriculture Research, held at the 16th IFOAM Organic World Conference in Cooperation with the International Federation of Organic Agriculture Movements (IFOAM) andthe-ConsorzioModenaBio, pp. 328–331, International Society of Organic Agriculture Research, Modena, Italy, June 2008.

[58] I. Sarangthem and J. S. Salam, "Recycling of the urban waste as manure on French bean (Phaseolus vulgaris) as test crop," Indian Journal of Agricultural Research, vol. 42, no. 2, pp. 124–127, 2008.

[59] B. Renuka and C. R. Sankar, "Effect of organic manures on growth and yield of tomato," South Indian Hort, vol. 49, pp. 216– 219, 2001.

[60] K. Thanunathan, S. Natarajan, R. Sentikumar, and K. Asulmurogan, "Effect of different sources of organic amendments on growth and yield of onion in mine spoil," Madras Agricultural Journal, vol. 84, no. 7, pp. 382–384, 1997.

[61] A. J. Lopes, N. P. Stamford, M. V. B. Figueired, N. A. Burity, and E. B. Ferraz, "Effect of vermicompost, mineral nitrogen and mineralizing agent on N fixation and yield in cowpea," RevistaBrasileira de Ciencia to Solo ˆ , vol. 20, pp. 55–62, 1996.

[62] R. H. Yadav and B. Vijayakumari, "Impact of vermicompost on biochemical characters of Chilli (Capsicum annum)," Journal of Ecotoxicology and Environmental Monitoring, vol. 14, no. 1, pp. 51–56, 2004.

[63] K. G. Dixit and B. R. Gupta, "Effect of farmyard manure, chemical and bio-fertilizers on yield and quality of rice (Oryza sativa L.) and soil properties," Journal of the Indian Society of Soil Science, vol. 48, no. 4, pp. 773–780, 2000

[64] T. U. Maheswari, K. Haripriya, P. Poonkodi, and S. Kamala kannan, "Effect of foliar application of organic nutrients on some quality indices and economics of chilli (Capsicum annum L," Advances in Plant Sciences, vol. 17, no. 1, pp. 259–262, 2004.

[65] R. S. Minhas and A. Sood, "Effet of inorganic and organic on yield and nutrients uptake by three crops in rotation in aid alfisol," Journal of the Indian Society of Soil Science, vol. 42, pp. 27–260, 1994.

[66] M. S. Clark, W. R. Horwath, C. Shennan, and K. M. Scow, "Changes in soil chemical properties resulting from organic and low-input farming practices," Agronomy Journal, vol. 90, no. 5, pp. 662–671, 1998.

[67] A. C. Gaur, S. Nilkantan, and K. S. Dargan, Organic Manures, ICAR, New Delhi, India, 2002.

[68] N. S. Subba Rao, "Organic matter decomposition," in Soil Microbiology, pp. 255–270, Oxford & IBH Publishing, New Delhi, India, 1999.

[69] L. R. Bulluck, M. Brosius, G. K. Evanylo, and J. B. Ristaino, "Organic and synthetic fertility amendments influence soil microbial, physical and chemical properties on organic and conventional farms," Applied Soil Ecology, vol. 19, no. 2, pp. 147– 160, 2002.

[70] R. L. Yadav, B. S. Dwivedi, and P. S. Pandey, "Rice-wheat cropping system: assessment of sustainability under green manuring and chemical fertilizer inputs," Field Crops Research, vol. 65, no. 1, pp. 15–30, 2000.

[71] S. Subbiah and K. Kumaraswamy, "Effect of manure-fertilizers on the yield and quality of rice and on soil fertility," Fertilizer News, vol. 45, no. 10, pp. 61–68, 2000.

[72] S. P. Singh, R. M. Kumar, and S. V. Subbaiah, "Effect of nitrogen and potassium application on grain yield of hybrid rice (Oryza sativa)," in Proceedings of the 2nd International Agronomy Congress, vol. 1, New Delhi, India, 2002.

[73] K. Laxminarayana and Patiram, "Effect of integrated use of inorganic, biological and organic manures on rice productivity and soil fertility in ultisols of Mizoram," Journal of Indian Society of Soil Science, vol. 54, no. 2, pp. 213–220, 2006.

[74] J. S. Urkurkar, S. Chitale, and A. Tiwari, "Effect of organic v/s chemical nutrient packages on productivity, economics and physical status of soil in rice (Oryza sativa)-Potato (Solanum tuberosum) cropping system in Chhattisgarh," Indian Journal of Agronomy, vol. 55, no. 1, pp. 6–10, 2010.

[75] A. Balasubramanian, R. Siddaramappa, and G. Rangaswami, "Effect of organic manuring on the activities of the enzymes hydrolysing sucrose and urea and on soil aggregation," Plant and Soil, vol. 37, no. 2, pp. 319–328, 1972.

[76] A. C. Gaur, K. V. Sadasivam, O. P. Vimal, R. S. Mathur, and S. K. Kavimandan, "Studies on the humification of organic matter in a red Rakar soil," Zentralblatt fur Bakteriologie, vol. 128, no. 1, pp. 149–161, 1973.

[77] A. C. Gaur and S. K. Prasad, "Effect of organic matter and inorganic fertilizers on plant parasitic nematodes," Indian Journal of Entomology, vol. 32, pp. 186–188, 1970.

Career Point International Journal of Research (CPIJR)
©2022 CPIJR | Volume 3 | Issue 3 | ISSN: 2583-1895
July-September-2024 | DOI: https://doi.org/10.5281/zenodo.14029517

[78] S. K. Prasad, S. D. Mishra, and A. C. Gaur, "Effect of soil amendments on nematodes associated with wheat followed by mung and maize," Indian Journal of Entomology, vol. 34, pp. 307–311, 1972.

[79] A. C. Gaur, "All Indian coordinated project on microbiological decomposition and recycling of farm and city wastes," Project Report, Indian Council of Agricultural Research, Poona, India, 1975.

[80] K. N. Sharma and K. N. Namdeo, "Effect of bio-fertilizers and phosphorus on growth and yield of Soybean (Glycine max L. Merill)," Crop Research, vol. 17, no. 2, pp. 160–163, 1999.

[81] S. Wu, E. R. Ingham, and D. Hu, "Soil microfloral and faunal populations in an organic ecosystem in Oregon, USA," in Proceedings of the 17th World Congress of Soil Science, vol. 5, p. 1756, Queen Sirkit National Convention Centre, Bangkok, Thailand, August 2002.

[82] L. R. Bulluck III, M. Brosius, G. K. Evanylo, and J. B. Ristaino, "Organic and synthetic fertility amendments influence soil microbial, physical and chemical properties on organic and conventional farms," Applied Soil Ecology, vol. 19, no. 2, pp. 147– 160, 2002.

[83] P. Bhattacharya and G. Chakraborty, "Current status of organic farming in India and other countries," Indian Journal of Fertilizers, vol. 1, no. 9, pp. 111–123, 2005.

[84] K. Singh and J. S. Bohra, "Net working project on diversification of rice wheat system through pulses and oilseeds," Project Report, UPCAR, 2009.

[85] S. T. Shende and R. Apte, "Azospirillum inoculation a highly remunerative input for agriculture," in Proceedings of the National Symposium on Biological Nitrogen Fixation, pp. 532–541, New Delhi, India, February 1982.

[86] S. Kalyan, "Integrated use of industrial and farm wastes with mineral and bio-activators for sustained rice productivity in rice based eco-system of Eastern Uttar Pradesh," First Annual Report, NATP, ICAR, New Delhi, India, 2003.

[87] A. C. Gaur, Handbook of Organic Farming and Biofertilizers, Ambica Book Publication, Jaipur, India, 2006

CAREER POINT INTERNATIONAL JOURNAL OF RESEARCH
Career Point International Journal of Research (CPIJR)
©2022 CPIJR | Volume 3 | Issue 3 | ISSN: 2583-1895
July-September-2024 | DOI: https://doi.org/10.5281/zenodo.14029596

Impacts and Management Strategies for *Parthenium hysterophorus*: A Weed of Global Importance

Rohitashv Nagar[1], Deepak Nagar[2], Dr. Narendra Kumar Bhinda[3], P. C. Choudhary[4]

School of Agricultural Sciences, Career Point University, Kota

[1,2,3,4] Assistant Professor, Department of Agronomy, School of Agricultural Sciences, Career Point University, Kota, Rajasthan, India Email: rohitashv.nagar@cpur.edu.in

Abstract

This paper explores the challenges and strategies in managing the invasive weed Parthenium hysterophorus. The use of chemical herbicides, such as glyphosate and atrazine, presents significant environmental hazards and has led to the development of resistant weed species. Alternative methods, including allelopathic control, have shown promise; specific plants like Cassia sericea and Imperata cylindrica effectively suppress Parthenium through natural chemical interactions. Biological control methods, leveraging natural enemies like microbial pathogens and insects, offer an environmentally friendly approach but require careful implementation. Integrated Weed Management (IWM) combines these biological controls with the use of suppressive plants to enhance effectiveness. Studies in Australia demonstrate that combining biological agents with suppressive plants like Mitchell grass and butterfly pea significantly reduces Parthenium growth, highlighting the potential for IWM as a sustainable solution for long-term weed control.

Key Words: Parthenium, Allelopathic, Weed Management

Introduction:

Parthenium hysterophorus L. (Asteraceae), a notorious invasive plant, has spread across many regions of the world beyond its native range in North and South America and the West Indies. According to Holm et al. [2], this highly invasive species ranks among the most troublesome weeds known today. It poses significant global challenges, causing severe health issues in humans and animals, such as dermatitis, asthma, and bronchitis, as well as agricultural losses and threats to biodiversity. It is widely believed that the seeds of this weed were introduced to India through grains imported from the USA under the US PL 480 scheme, also known as "Food for Peace," a food assistance program of the US government. The weed rapidly spread across nearly all states in India, becoming a naturalized species. In India, Parthenium was first identified in Pune (Maharashtra) by Professor Paranjape in 1951, as stray plants on rubbish heaps, and was later reported by Rao [3] as a new species in the country. However, the earliest record of this species in India dates back to 1814, when it was documented by Roxburgh, the father of Indian Botany, in his book Hortus Bengalensis [3, 4]. Since the weed became a global menace, including in India, various control methods have been employed, such as mechanical, competitive replacement (allelopathy), chemical, and biological control. Despite these efforts, the weed has proven difficult to manage due to various limitations. Biological control, which involves the deliberate use of natural enemies like insects, bio-herbicides, nematodes, snails, and competitive plants, is gaining traction as an effective and environmentally friendly alternative to conventional weed control methods [5].

The genus name Parthenium is derived from the Latin word parthenice, referring to the plant now known as Tanacetum parthenium (L.) Bernh., or "feverfew;" hysterophorus comes from the Greek words hystera (womb) and phoros (bearing), alluding to the plant's prolific seeding habit [8]. Commonly referred to as bitter weed, carrot weed, broom bush, and congress grass in India, it is also known as whitetop, escobar amarga, and feverfew in the Caribbean, and false ragweed and ragweed parthenium in the USA. Parthenium hysterophorus L. belongs to the tribe Heliantheae of the family Asteraceae, a highly diverse family with a cosmopolitan distribution [6].

In India, Parthenium hysterophorus L., also known as carrot weed, white top, or congress grass, is a herbaceous, erect annual plant of the family Asteraceae. It is commonly referred to as "gajar ghas" due to its resemblance to the carrot plant. The plant is believed to have originated from Mexico, America, Trinidad, and Argentina. After its noticeable presence was first recorded in Pune (Maharashtra) in 1956, Parthenium has spread like wildfire throughout India. Initially, Parthenium was primarily a problem in waste and vacant land, but it has since become a significant weed in crops as well. In forested areas, it poses a serious threat in grasslands, particularly in national parks, where it disrupts the herbivore-carnivore food chain. Currently, approximately 35 million hectares of land are estimated to be infested with Parthenium, and its spread into crop areas in recent years is particularly alarming.

How Parthenium Spreads:

Parthenium primarily spreads through its seeds, with the potential to produce up to 154,000 seeds per square meter. A single plant can yield between 15,000 to 25,000 seeds. These seeds are extremely lightweight and can be easily dispersed by wind, water, or various human activities. Additionally, Parthenium can regenerate from cut or broken parts, further aiding its spread. Its rapid proliferation in India is largely due to its allelopathic properties and the absence of natural enemies such as insects and diseases.

Why Parthenium is a Dangerous Weed:

Parthenium is a poisonous, invasive, problematic, allergenic, and aggressive weed that poses a significant threat to both humans and livestock. In India and Australia, it is recognized as a leading cause of dermatitis, asthma, and various nasal-dermal and naso-bronchial conditions. Beyond its health impacts, Parthenium also causes issues like blocking pathways and diminishing the aesthetic value of parks, gardens, and residential areas.

Morphology of the Plant:

Parthenium hysterophorus L., belonging to the family Asteraceae (tribe: Heliantheae), is a fast-growing, erect, and highly branched annual or ephemeral herb. The plant's life cycle consists of two distinct phases: the juvenile or vegetative stage, and the adult or reproductive stage. During the juvenile stage, the plant forms a rosette of large, dark green, simple, radicle, and pinnatisect leaves, which are small and non-flowering. These large lower leaves spread out flat on the ground like a carpet, preventing any other vegetation from growing underneath them [9]. In the adult stage, the plant becomes erect and extensively branched, with a deep taproot system that can reach up to 2 meters in height. The stem is hairy, octagonal, and longitudinally grooved, becoming tough and woody as the plant matures into a hardy bush. The leaves are simple, alternate, and pinnately or bipinnately dissected, measuring 20–30 × 12–25 cm, and they become smaller towards the branch tips. Both the stem and leaf surfaces are covered with four types of glandular and non-glandular, multicellular white trichomes. The flowers are creamy white, approximately 4 mm across, and emerge from the leaf forks. The plant produces an enormous number of pollen grains, about 624 million per plant, which are anemophilous (wind-pollinated). Each flower produces four to five black, wedge-shaped seeds and that are about 2 mm long, with thin white scales, making them difficult to see with the naked eye. The plant is a

Career Point International Journal of Research (CPIJR)
©2022 CPIJR | Volume 3 | Issue 3 | ISSN: 2583-1895
July-September-2024 | DOI: https://doi.org/10.5281/zenodo.14029596

prolific seed producer, capable of producing up to 25,000 seeds per plant, contributing to a large seed bank in the soil [10].

Habitat:

Parthenium hysterophorus thrives in various environments, including wastelands, public lawns, orchards, forestlands, flood plains, agricultural areas, urban areas, overgrazed pastures, industrial zones, playgrounds, roadsides, railway tracks, and residential plots. Drought conditions and reduced pasture cover create ideal conditions for the establishment of parthenium weed. Although the weed can grow in most soil types, it is particularly dominant in alkaline, clay loam soils.

Harmful Effects:

Parthenium hysterophorus is considered the most dangerous terrestrial weed due to its harmful impacts on both human health and biodiversity, as detailed below.

Effects on Ecosystem:

Parthenium has been reported to cause significant habitat changes in native Australian grasslands, open woodlands, riverbanks, and flood plains [9]. It aggressively colonizes wastelands, roadsides, railway sides, watercourses, cultivated fields, and overgrazed pastures. Between 2001 and 2007, the weed invaded 14.25 million hectares of farmland, a dramatic increase from the 2 million hectares invaded between 1991 and 2000 [10].

Effects on Crops:

Parthenium contains chemicals such as parthenin, hysterin, hymenin, and ambrosin, which exert strong allelopathic effects on various crops. Parthenin, in particular, has been identified as an inhibitor of germination and radicle growth in both dicot and monocot plants [13]. The weed also affects nodulation in legumes by inhibiting the activity of nitrogen-fixing and nitrifying bacteria, including Rhizobium, Actinomycetes, Azotobacter, and Azospirillum. The plant produces an enormous number of pollen grains (approximately 624 million per plant), which are dispersed in clusters of 600–800 grains and can settle on vegetative and floral parts, including the stigmatic surface, inhibiting fruit set in crops such as tomato, brinjal, beans, capsicum, and maize. In India, P. hysterophorus has been reported to cause up to a 40% yield decline in agricultural crops [14]. In Ethiopia, grain yield losses in sorghum (Sorghum bicolor L. Moench) of between 40% and 97% have been reported when Parthenium is left uncontrolled throughout the season [7, 15]. In Australia, P. hysterophorus infests approximately 170,000 km² of prime grazing land in Queensland, resulting in economic losses of around $16.8 million per year to the pasture industry [16]. On cracking clay soils with annual rainfall between 600 and 800 mm, P. hysterophorus has been estimated to reduce the carrying capacity of affected farms by about 40% [17, 18]. Additionally, the weed serves as a collateral host for many crop diseases caused by viruses.

Effects on Animals:

Parthenium is toxic to animals, causing dermatitis with pronounced skin lesions in various species, including horses and cattle. When ingested, it can cause mouth ulcers and excessive salivation, and a diet containing 10–50% of this weed can be fatal to cattle [19]. In dogs, it causes anorexia, pruritus, alopecia, diarrhea, and eye irritation. The consumption of buttermilk and tainted meat from buffaloes, cows, and goats that have grazed on grass mixed with Parthenium can lead to acute illness in humans. Additionally, extracts from the weed have been shown to significantly reduce the white blood cell count in rats, indicating its potential to weaken the immune system [20].

Effects on Human Beings:

The pollen grains, airborne dried plant parts, and roots of Parthenium cause various allergic reactions in humans, including contact dermatitis, hay fever, asthma, and bronchitis. Common allergens found in this weed include parthenin, coronopilin, tetraneuris, and ambrosin. The pollen of Parthenium is particularly associated with asthma (allergic bronchitis), especially in children playing outdoors and in adults and the elderly. Skin contact with the plant can cause dermatitis, and the condition can spread across the body, leading to significant discomfort [21].

Clinically, Parthenium dermatitis can present in five distinct patterns:

1. Classical Pattern (Airborne Contact Dermatitis, ABCD): Affects the face, especially the eyelids, neck, V of the chest, and cubital and popliteal fossae.

2. Chronic Actinic Dermatitis (CAD) Pattern: Involves exposed areas such as the forehead, ears, cheeks, neck, and forearms, with relative sparing of non-sun-exposed areas like the eyelids, retroauricular areas, and undersurface of the chin.

3. Mixed Pattern: A combination of the classical and CAD patterns, manifesting as scattered, infiltrated, scaly papules on exposed parts and dermatitis on the eyelids, flexures of extremities, and neck.

4. Photosensitive Lichenoid Eruption Pattern: Presents with pruritic, discrete, flat, violaceous papules, and plaques on sun-exposed parts such as the forehead, ears, cheeks, upper chest, back, and forearms, resembling photosensitive lichenoid eruptions.

5. Prurigo Nodularis-like Pattern: Characterized by multiple hyperkeratotic papules and nodules on the extremities, with histopathologic features similar to prurigo nodularis [12, 22].

Control of Parthenium:

Singh (1997) identified the use of bio-control agents (insects and fungal pathogens) and the exploitation of competitive plants (allelopathy) as the most economical and practical methods for managing Parthenium. However, despite these efforts, the weed has not been reduced below the threshold level and continues to threaten biodiversity and pose significant health risks to humans and animals. Various control methods, including physical, chemical, bio-herbicidal, and integrated approaches, are being practiced worldwide and are discussed below.

Physical Control:

Manual uprooting of Parthenium before it flowers and sets seed is the most effective method for controlling this weed. Uprooting after seed setting can actually increase the infestation area. Some landholders have successfully ploughed the weed during its rosette stage before it seeds, but this must be followed by planting a crop or direct seeding of perennial pasture. Physical control, which involves hand weeding, is time-consuming and unpleasant, compounded by the health hazards associated with handling Parthenium. Burning has been employed as a strategy to manage the weed, but it is not considered effective for Parthenium control. Research indicates that burning for other purposes (e.g., woody weed control) does not result in increased Parthenium infestation, provided the pasture is allowed to recover before livestock are

Career Point International Journal of Research (CPIJR)
©2022 CPIJR ǀ Volume 3 ǀ Issue 3 ǀ ISSN: 2583-1895
July-September-2024 | DOI: https://doi.org/10.5281/zenodo.14029596

reintroduced. However, burning requires large amounts of fuel and destroys other economically important plants growing nearby, making it an inadequate control method [23, 24].

Fig. No-1 Manual uprooting of Parthenium at Career Point University, Kota

Chemical Control:

Chemical control is effective in areas where Parthenium natural enemies are absent. Herbicides such as chlorimuron ethyl, glyphosate, atrazine, ametryn, bromoxynil, and metsulfuron are known to be highly effective in controlling this weed. Studies [25–27] have shown that applying 2,4-D EE (0.2%) and metribuzin (0.25% and 0.50%) is particularly effective for controlling Parthenium 15 days after spraying (DAS), resulting in the complete eradication of the weed population without allowing further emergence. Khan et al. [28] reported that the timing of herbicidal application is crucial, with the rosette stage being the most effective time for control in wastelands, non-cropped areas, along railway tracks, water channels, and roadsides. Among various herbicides, glyphosate and metribuzin have shown the highest mortality rates 4 weeks after treatment (WAT) at both rosette and bolted stages, outperforming 2,4-D, triasulfuron + terbutryn, bromoxynil + MCPA, and atrazine + s-metolachlor. Pendimethalin was found to be the least effective treatment for both growth stages. Overall, herbicides are more effective on rosette-stage Parthenium plants than on bolted plants. In open wastelands, non-cropped areas, and along railway tracks and roadsides, spraying a solution of common salt (sodium chloride) at a 15–20% concentration has also been effective.

Mechanical Management:

In many crop fields, Parthenium germinates profusely when left fallow for one season. In such cases, deep ploughing before the weed flowers is both economical and effective, as the weed can be turned into green manure. Care should be taken to spot-treat any remaining plants with chemicals, as those not fully buried may regenerate.

Cultural Management:

Farmers should be advised to plant fast-growing crops like sorghum and Sesbania (daincha) to suppress Parthenium growth, particularly in fields that are left fallow.

Legal Management:

State and central governments should declare Parthenium a noxious weed and implement laws holding landowners responsible for controlling it on vacant plots. Municipalities, the transport ministry (for roadsides), the railway ministry (for railway tracks), and irrigation departments (for canal bunds) should take appropriate steps to control the weed using available methods.

Chemical Management:

In areas where manual uprooting is not feasible due to labor shortages or high costs, Parthenium can be controlled using glyphosate (1–1.5%) for total vegetation control or metribuzin (0.3–0.5%) or 2,4-D (2–2.5 kg a.i.) where grasses need to be preserved. In different crops, herbicide use should be guided by weed scientists, as different crops require different herbicides. For example, alachlor (2.0 kg a.i.) can be used as a pre-emergence treatment to control Parthenium in soybean, rajmaha, banana, and tomato crops, while metribuzin (0.50–0.75 kg) can be used as a pre-emergence treatment just after sowing in potato, tomato, and soybean crops. Atrazine is recommended for use in maize.

Biological Control:

Biological control involves the intentional use of natural enemies to manage harmful weeds. It is cost-effective, environmentally safe, and poses no threat to non-target organisms, biodiversity, or the environment. Biological control agents include insects, fungi, nematodes, snails, slugs, and competitive plants, with insects receiving the most attention in Parthenium

Career Point International Journal of Research (CPIJR)
©2022 CPIJR | Volume 3 | Issue 3 | ISSN: 2583-1895
July-September-2024 | DOI: https://doi.org/10.5281/zenodo.14029596

control. Biological control is self-perpetuating and can spread on its own, making it easier to integrate with other control methods. Among the biological control methods, using *Zygogramma bicolorata* has emerged as one of the most promising. Under biological control programs, host-specific bioagents from the weed's native range are imported into other countries where the weed has become invasive.

Public Awareness and Capacity Building Programs:

For successful Parthenium management at the national level, public participation and awareness are crucial. Each participating unit should organize Parthenium Awareness Days, weeks, fortnights, or months. These programs should include live demonstrations, uprooting activities involving the public, students, and employees, photo exhibitions, video presentations, and rallies. Media should be invited to cover these activities to raise awareness about the weed. Training for various stakeholders is also essential for the successful implementation of Parthenium management. Master trainers from different states may be trained by the Directorate of Weed Research, Jabalpur, who can then disseminate this knowledge to other stakeholders. Emphasis should be placed on spreading the message through electronic and print media. The initial culture of the bioagent Z. bicolorata may also be provided by the Directorate of Weed Research for further mass multiplication and dissemination, along with training for stakeholders.

Fig. No-2 Public Awareness and Capacity Building Programs at Kasar Village

Disadvantages of Herbicides:

The use of chemical herbicides comes with several disadvantages, including environmental hazards and the development of resistance among many weeds. Resistance has been documented against herbicides like atrazine, 2, 4-D, metribuzin, paraquat (Gramoxone), trifluralin, diphenamid, and glyphosate [29–31]. Glyphosate, in particular, is one of the most toxic herbicides, with many wild plant species being damaged or killed by applications as low as 10 micrograms per plant. Moreover, glyphosate can be more harmful to wild flora than many other herbicides. Atrazine is highly persistent in soil and has been classified as a restricted-use pesticide (RUP) in the USA due to its potential for groundwater contamination [32].

Allelopathic Control:

The term "allelopathy" was introduced by Molisch (1937) and generally refers to the harmful effect of one plant species on the seed germination, growth, and reproduction of another. Numerous plants have been reported to possess allelopathic potential, and efforts have been made to utilize this property for weed control [33]. Parthenium can be competitively suppressed by planting species such as Cassia sericea, C. tora, C. auriculata, Croton bonplandianum, Amaranthus spinosus, Tephrosia purpurea, Hyptis suaveolens, Sida spinosa, and Mirabilis jalapa, which are effective in natural habitats [34]. In India, a study revealed that Cassia sericea reduced Parthenium biomass by 70% and population density by 52.5% [35]. Another study found that aqueous extracts from Imperata cylindrica, Desmostachya bipinnata, Otcantium annulatum, and Sorghum halepense significantly suppressed seedling growth and germination of Parthenium [36]. Additionally, crop rotation using Marigold (Tagetes spp.) during the rainy season has been effective in reducing Parthenium infestation in cultivated areas.

Both the root and shoot extracts of three allelopathic grasses, namely Dicanthium annulatum, Cenchrus pennisetiformis, and Sorghum halepense, have been shown to reduce germination and suppress early seedling growth of the exotic weed P. hysterophorus. Aqueous foliar extracts of Azadirachta indica, Aegle marmelos, and Eucalyptus tereticornis have been found to completely inhibit the seed germination of Parthenium and may be used for its control.

Biological Control:

Biological control is an environmentally sound and effective method of reducing or mitigating pests and their effects through the use of natural enemies. Over the past three to four decades, significant emphasis has been placed on controlling Parthenium through various bio-control agents, including microbial pathogens, insects, and botanicals [24, 37]. Among the different bio-control strategies, the use of plant pathogens for weed control has gained acceptance as a practical, safe, and environmentally beneficial method applicable to agro-ecosystems [38].

There are two basic strategies for implementing biological weed control: the introduction of foreign pathogenic organisms, known as the “classical approach,” and the “augmentative” or “bio-herbicidal approach,” where the population of existing pathogenic organisms (either native or introduced) is increased through mass rearing. In epidemiological terms, these strategies are referred to as the “inoculative” and “inundative” strategies, respectively [39].

Integrated Weed Management:

Neither the classical nor the bio-herbicidal strategies, when applied alone, are sufficient to suppress Parthenium effectively. However, Integrated Pest Management (IPM) has gained attention in recent years as a means of reducing pest-related losses while minimizing reliance on chemical controls, thereby promoting the long-term sustainability of agricultural systems. In Australia, to complement the classical biological control approach with other management tactics, two selected suppressive plants native Mitchell grass (*Astrebella squrossa*) and the introduced legume butterfly pea (*Clitoria ternatea*) along with two biological control agents a leaf- and seed-feeding beetle (*Zygogramma bicolorata*) and a stem-galling moth (*Epiblema strenuana*) have been used to control Parthenium under an integrated weed management program. The suppressive plants significantly inhibited weed growth even in the absence of the biological control agents. This suppressive ability was further enhanced when one of the biological agents was present. Research conducted in Australia has demonstrated that Parthenium weed can be more effectively managed by integrating existing biological control strategies with the use of suppressive plants.

This approach reduced the growth of Parthenium by 60–80% in the first year and 47–91% in the second year. The biomass of suppressive plants was 6–23% greater when biological control agents were present, demonstrating that Parthenium weed can be more effectively managed by combining the current biological control strategies with selected suppressive plant species.

Conclusion:

Parthenium hysterophorus is a highly invasive and harmful weed that poses significant threats to agriculture, biodiversity, and human and animal health across many regions, particularly in India. Its rapid spread is facilitated by its prolific seed production and allelopathic properties, which inhibit the growth of other plants and make it difficult to manage. Despite various control methods, including mechanical, chemical, and biological strategies, the weed continues to thrive and spread, underscoring the need for integrated management approaches. Biological control, which leverages natural enemies such as insects and pathogens, has shown promise as an environmentally friendly alternative to traditional methods. However, no single strategy has proven entirely effective on its own. Integrated Weed Management (IWM), which combines biological control with other methods like the use of suppressive plants, offers a more sustainable and comprehensive approach to controlling *Parthenium*. Continued research, public awareness, and coordinated efforts at national and international levels are crucial to mitigate the impact of this weed and protect ecosystems, agriculture, and public health from its adverse effects.

References:

1. Picman J., Picman A. K. Autotoxicity in *Parthenium hysterophorus* and its possible role in control of germination. *Biochemical Systematics and Ecology*. 1984;12(3):287–292. doi: 10.1016/0305-1978(84)90051-6.

2. Holm L., Doll J., Holm E., Pancho J. V., Herberger J. P. *World Weeds: Natural Histories and Distribution.* New York, NY, USA: John Wiley & Sons; 1997.

3. Rao R. S. *Parthenium*, a new record for India. *Journal of Bombay Natural History Society*. 1956;54:218–220.

4. Roxburg W. *Hortus Bengalensis or a Catalogue of the Plants Growing in the Honourable East India Company's Botanic Garden at Calcutta.* Serampore, India: The Mission Press; 1814.

5. Kumar S. Biological control of Parthenium in India: status and prospects. *Indian Journal of Weed Science.* 2009;41(1-2):1–18.

6. Navie S. C., McFadyen R. E., Panetta F. D., Adkins S. W. The biology of Australian Weeds *Parthenium hysterophorus* L. *Plant Protection Quarantine*. 1996;11:76–88.

7. Aneja K. R. *From Ethnomycology to Fungal Biotechnology.* London, UK: Plenum; 1999. Biotechnology for the production and enhancement of mycoherbicide potential; pp. 91–114.

Career Point International Journal of Research (CPIJR)
©2022 CPIJR | Volume 3 | Issue 3 | ISSN: 2583-1895
July-September-2024 | DOI: https://doi.org/10.5281/zenodo.14029596

8. Parsons W. T., Cuthbertson E. G. *Noxious Weeds of Australia*. Melbourne, Australia: Inkata Press; 1992. [Google Scholar]

9. Lakshmi C., Srinivas C. R. Type I hypersensitivity to Parthenium hysterophorus in patients with parthenium dermatitis. *Indian Journal of Dermatology, Venereology and Leprology*. 2007;73 (2):103–105. doi: 10.4103/0378-6323.31895.

10. Javaid A., Adrees H. Parthenium management by cultural filtrates of phytopathogenic fungi. *Natural Product Research*. 2009;23(16):1541–1551. doi: 10.1080/14786410902726167.

11. Monaco J. T., Weller S. C., Ashton F. M. *Weed Biology and Ecology*. 4th. NewYork, NY, USA: Academic Publisher; 2001.

12. Aneja K. R. *Botanical Researches in India*. Udaipur, India: Himanshu Publications; 1991. Deadly weed *Parthenium hysterophorus* and its control-a review; pp. 258–269.

13. Gunaseelan N. V. Impact of anaerobic digestion on inhibition potential of *Parthenium* solids. *Biomass and Bioenergy*. 1998;14(2):179–184. doi: 10.1016/S0961-9534(97)10019-8.

14. Khosla S. N., Sobti S. N. Effective control of *Parthenium hysterophorus* L. *Pesticides*. 1981;15(4):18–19.

15. Tamado T., Ohlander L., Milberg P. Interference by the weed *Parthenium hysterophorus* L. with grain sorghum: influence of weed density and duration of competition. *International Journal of Pest Management*. 2002;48(3):183–188. doi: 10.1080/09670870110101739.

16. Chippendale J. F., Panetta F. D. The cost of *Parthenium* weeds to the Queensland cattle industry. *Plant Protection Quarantine*. 1994;9:73–76.

17. Fessehaie R., Chichayibelu M., Giorgis M. H. Spread and ecological consequences of *Parthenium hysterophorus* in Ethiopia. *Applied and Environmental Microbiology*. 2005;6:11–21.

18. Mcconnachie A. J., Strathie L. W., Mersie W., et al. Current and potential geographical distribution of the invasive plant *Parthenium hysterophorus* (Asteraceae) in eastern and southern Africa. *Weed Research*. 2011;51(1):71–84. doi: 10.1111/j.1365-3180.2010.00820.x.

19. Narasimhan T. R., Ananth M., Swamy M. N., Babu M. R., Mangala A., Rao P. V. S. Toxicity of *Parthenium hysterophorus* L. to cattle and buffaloes. *Experientia*. 1977; 33(10):1358–1359. doi: 10.1007/BF01920179.

20. Yadav N., Saha P., Jabeen S., et al. Effect of methanolic extract of Parthenium hysterophorus on haematological parameters in wistar albino rat. *The Bioscan International Journal of Life Sciences.* 2010;2: 357–363.

21. Wiesner M., Tessema T., Hoffmann A., et al. *Impact of the Pan-Tropical Weed Parthenium hysterophorus L. on Human Health in Ethiopia.* Berlin, Germany: Institute of Horticultural Science, Urban Horticulture; 2007.

22. Sharma V. K., Verma P., Maharaja K. Parthenium dermatitis. *Photochemical and Photobiological Sciences.* 2013;12(1):85–94. doi: 10.1039/c2pp25186h.

23. Kushwaha V. B., Maurya S. Biological utilities of *Parthenium hysterophorus* . *Journal of Applied Natural Science.* 2012;4(1):137–143.

24. Ray P., Gour H. N. Integrated management of *Parthenium hysterophorus* L. (Asteraceae): a weed of worldwide significance. *Indian Society of Mycology and Plant Pathology.* 2012;5: 605–632.

25. Javaid A. Efficacy of some chemical herbicides against *Parthenium hysterophorus* L. *Pakistan Journal of Weed Science Research.* 2007;13: 93–98.

26. Mishra J. S., Bhan V. M. Efficacy of sulfonyl urea herbicides against *Parthenium* hysterophorus. *Weed News.* 1994; 1, article 16

27. Gaikwad C. B., Kasture M. C., Lambade B. M. Evaluation of herbicides for control of *Parthenium* in waste land. *Indian Journal of Weed Science.* 2008;40(1-2):79–81.

28. Khan H., Khan B. M., Hassan G., Khan M. A. Chemical control of *Parthenium hysterophorus* L. at different growth stages in non-cropped area. *Pakistan Journal of Botany.* 2012; 44(5):1721–1726.

29. Njoroge J. M. Tolerance of *Bidens pilosa* L. and *Parthenium hysterophorus* L. to parquat (Gramooxone) in Kenya. *Kenya Coffee.* 1991; 56:999–1001.

30. Singh S., Yadav A., Balyan R. S., Malik R. K., Singh M. Control of ragweed parthenium (*Parthenium hysterophorus*) and associated weeds. *Weed Technology.* 2004;18(3):658–664. doi: 10.1614/WT-03-128R2.

31. Vila-Aiub M. M., Vidal R. A., Balbi M. C., Gundel P. E., Trucco F., Ghersa C. M. Glyphosate-resistant weeds of South American cropping systems: an overview. *Pest Management Science.* 2008;64(4):366–371. doi: 10.1002/ps.1488.

32. Ware G. W. *Fundamentals of Pesticides: A Self Instruction Guide.* 2nd. Fresno, Calif, USA: Thomson Publications; 1986.

33. Knox J. *An investigation on suppressing capabilities of some allelopathic plants against Parthenium hysterophorus L. [Ph.D. thesis]* Agra, India: Dr. B. R. Ambedkar University; 2008.

34. Wahab S. Management of *Parthenium* through an integrated approach initiatives, achievements and research opportunities in India. Proceedings of the 2nd International Conference on Parthenium Management; 2005; Bangalore, India. University of Agricultural Sciences; pp. 36–43.

35. Kandasamy O. S., Sankaran S. Biological suppression of parthenium weed using competitive crops and plants. Proceeding of the 1st International Conference on Parthenium Management; 1997; Dahrwad, India. University of Agricultural Sciences; pp. 33–36.

36. Javaid A., Anjum T., Bajwa R. Biological control of *Parthenium* II: allelopathic effect of *Desmostachya bipinnata* on distribution and early seedling growth of *Parthenium hysterophorus* L. *International Journal of Biology and Biotechnology*. 2005;2(2):459–463.

37. Watson A. K., Wymore L. A. *New Directions in Biological Control: Alternatives for Suppressing Agricultural Pests and Diseases.* New York, NY, USA: Academic Press; 1990. Identifying limiting factors in the biocontrol of weeds; pp. 305–316.

38. Aneja K. R. *Antimicrobial Resistance from Emerging Threats to Reality*. New Delhi, India: Narosa Publishing House; 2009. Biotechnology: an alternative novel strategy in agriculture to control weeds resistant to conventional herbicides; pp. 160–173.

39. El-Sayed W. Review biological control of weeds with pathogens: current status and future trends. *Journal of Plant Disease Protection.* 2005;112 (3):209–221.

CAREER POINT INTERNATIONAL JOURNAL OF RESEARCH
Career Point International Journal of Research (CPIJR)
©2022 CPIJR | Volume 3 | Issue 3 | ISSN: 2583-1895
July-September-2024 | DOI: https://doi.org/10.5281/zenodo.14029535

Role of Phosphate Solubilizing Bacteria (PSB) and Organic Amendments in Chickpea Cultivation

Rohitashv Nagar[1], Dr. Narendra Kumar Bhinda[2], Deepak Nagar[3], Chetan Nagar[4]

School of Agricultural Sciences, Career Point University, Kota

[1,2,3,4] Assistant Professor, Department of Agronomy, School of Agricultural Sciences, Career Point University, Kota, Rajasthan, India Email: rohitashv.nagar@cpur.edu.in

Abstract

Chickpea (*Cicer arietinum* L.) is a critical pulse crop, especially in developing regions, due to its nutritional benefits and role in enhancing soil fertility through symbiotic nitrogen fixation with Rhizobium bacteria. However, phosphorus (P) deficiency in soils poses a major challenge to chickpea production. Phosphorus, vital for energy transfer, photosynthesis, and root development, is often rendered unavailable to plants due to its tendency to form insoluble complexes in soil. Traditional reliance on chemical phosphorus fertilizers, while providing immediate relief, has led to environmental degradation and unsustainable resource depletion. This review examines sustainable alternatives to chemical fertilizers, focusing on the use of phosphate solubilizing bacteria (PSB) and organic amendments. PSB enhance phosphorus availability by converting insoluble forms into soluble ones through mechanisms like organic acid secretion, enzyme production, and siderophore release. Organic amendments, including compost, vermicompost, and farmyard manure (FYM), improve soil structure, microbial activity, and phosphorus cycling. The combined use of PSB and organic amendments offers a synergistic approach that not only boosts phosphorus availability but also enhances chickpea yield, quality, and overall soil health.

The integration of PSB and organic amendments presents significant environmental and economic benefits by reducing chemical fertilizer dependency, promoting sustainable soil management, and potentially lowering production costs. Despite these advantages, challenges such as variability in PSB effectiveness and the availability of organic materials remain. Future research should focus on optimizing these biological and organic inputs for different soil types and conditions, and on supporting policies that promote sustainable agricultural practices.1.

Keywords: Phosphate Solubilizing Bacteria (PSB), Organic Amendments, Chickpea Cultivation, Soil Fertility, Sustainable Agriculture, Crop Yield Improvement, Microbial Inoculants

1. Introduction

Chickpea (*Cicer arietinum* L.) is one of the most vital pulse crops worldwide, playing a crucial role in ensuring food security, particularly in developing countries. As a rich source of protein, fiber, vitamins, and essential minerals, chickpea is a staple food for millions of people, particularly in South Asia and the Mediterranean region. In addition to its dietary importance, chickpea also enhances soil fertility through its ability to fix atmospheric nitrogen in symbiosis with Rhizobium bacteria. Despite these benefits, one of the major constraints to chickpea production is the limited availability of phosphorus (P) in the soil. Phosphorus is a macronutrient that is essential for several key physiological and biochemical processes in plants, including energy transfer (via ATP), photosynthesis, root development, and nutrient transport. It also plays a critical role in the formation of nucleic acids and cell membranes, thus directly affecting plant growth and productivity. However, phosphorus in soils is often immobilized and becomes unavailable to plants, largely because it tends to form insoluble complexes with calcium, iron, and aluminum. As a result, a significant portion of the phosphorus applied to soils, particularly in alkaline or acidic conditions, becomes "fixed" and inaccessible to plants, leading to widespread phosphorus deficiency.

Phosphorus deficiency in soils is a major issue globally, affecting crop yields and limiting agricultural productivity, especially in developing countries with poor soil management practices. To overcome this problem, farmers have traditionally relied on chemical phosphorus fertilizers, such as superphosphates, which are readily available to plants. While these fertilizers provide an immediate solution to phosphorus deficiency, they come with several drawbacks. Excessive and prolonged use of chemical fertilizers can lead to environmental degradation, including soil acidification, water pollution from runoff, and a decline in soil biodiversity. Moreover, the mining of phosphate rock, the primary source of phosphorus fertilizers, is not sustainable in the long term, as it depletes a finite natural resource.

Given these challenges, sustainable alternatives to chemical phosphorus fertilizers have become a key focus of agricultural research. One promising solution lies in the use of phosphate solubilizing bacteria (PSB), a group of beneficial microorganisms capable of converting insoluble phosphorus into forms that are readily accessible to plants. PSB achieve this through various mechanisms, including the secretion of organic acids that lower the soil pH and dissolve bound phosphorus, the production of enzymes that release phosphorus from organic matter, and the production of other metabolites that aid in phosphorus solubilization. In addition to PSB, organic amendments such as compost, vermicompost, and farmyard manure (FYM) can further enhance phosphorus availability in the soil. These organic materials not only provide a slow-release source of nutrients, including phosphorus, but also improve soil structure, increase microbial activity, and enhance the overall health and fertility of the soil. When used in combination with PSB, organic amendments create a synergistic effect that enhances phosphorus solubilization and availability, leading to improved plant growth, higher yields, and better soil health.

This review explores the combined role of phosphate solubilizing bacteria and organic amendments in chickpea cultivation. It highlights their potential to enhance phosphorus availability in soils, improve chickpea yield and quality, and promote sustainable agricultural practices. By integrating these biological tools into chickpea farming, it is possible to reduce the reliance on chemical fertilizers, mitigate environmental risks, and ensure long-term soil fertility and productivity.

2. Phosphorus in Chickpea Cultivation

Phosphorus is a critical, non-renewable nutrient essential for the growth and development of leguminous crops like chickpea (Cicer arietinum L.). It plays a vital role in several plant processes, including root development, energy transfer through ATP, photosynthesis, and the synthesis of nucleic acids. For chickpeas, phosphorus is particularly important for nodulation—the process by which the plant forms a symbiotic relationship with nitrogen-fixing bacteria (Rhizobium), allowing it to convert atmospheric nitrogen into a usable form. This nitrogen fixation is crucial for enhancing soil fertility and maximizing chickpea yield.

However, phosphorus deficiency is a common issue in soils globally. In most agricultural soils, phosphorus tends to form insoluble complexes with elements such as calcium in alkaline soils and aluminum or iron in acidic soils. This leads to the immobilization of phosphorus, making it unavailable for plant uptake. As a result, even soils that contain significant amounts of phosphorus often fail to provide adequate levels of this nutrient to crops, including chickpea.

To address phosphorus deficiency, farmers traditionally use chemical phosphorus fertilizers such as superphosphates. While these fertilizers provide an immediate source of available

Career Point International Journal of Research (CPIJR)
©2022 CPIJR | Volume 3 | Issue 3 | ISSN: 2583-1895
July-September-2024 | DOI: https://doi.org/10.5281/zenodo.14029535

phosphorus, their continuous and excessive use can lead to environmental concerns, such as water contamination from runoff, soil acidification, and a reduction in beneficial soil microorganisms. Furthermore, phosphorus rock, the primary source for these fertilizers, is a finite resource, making the over-reliance on chemical fertilizers unsustainable in the long term. An alternative approach involves natural and biological interventions, such as the use of phosphate solubilizing bacteria (PSB) and organic amendments like compost, vermicompost, and farmyard manure (FYM). PSB can release phosphorus from insoluble compounds, making it more accessible to plants, while organic amendments enhance soil structure and microbial activity, further increasing phosphorus availability. This sustainable combination of biological and organic inputs can improve phosphorus uptake, support healthy plant growth, and increase chickpea yield without the environmental drawbacks associated with chemical fertilizers.

3. Role of Phosphate Solubilizing Bacteria (PSB)

Phosphate solubilizing bacteria (PSB) are beneficial microorganisms that play a crucial role in enhancing phosphorus availability for plants by converting insoluble forms of phosphorus, such as calcium phosphate, iron phosphate, and aluminum phosphate, into soluble forms that plants can readily absorb. This transformation is achieved through several key mechanisms:

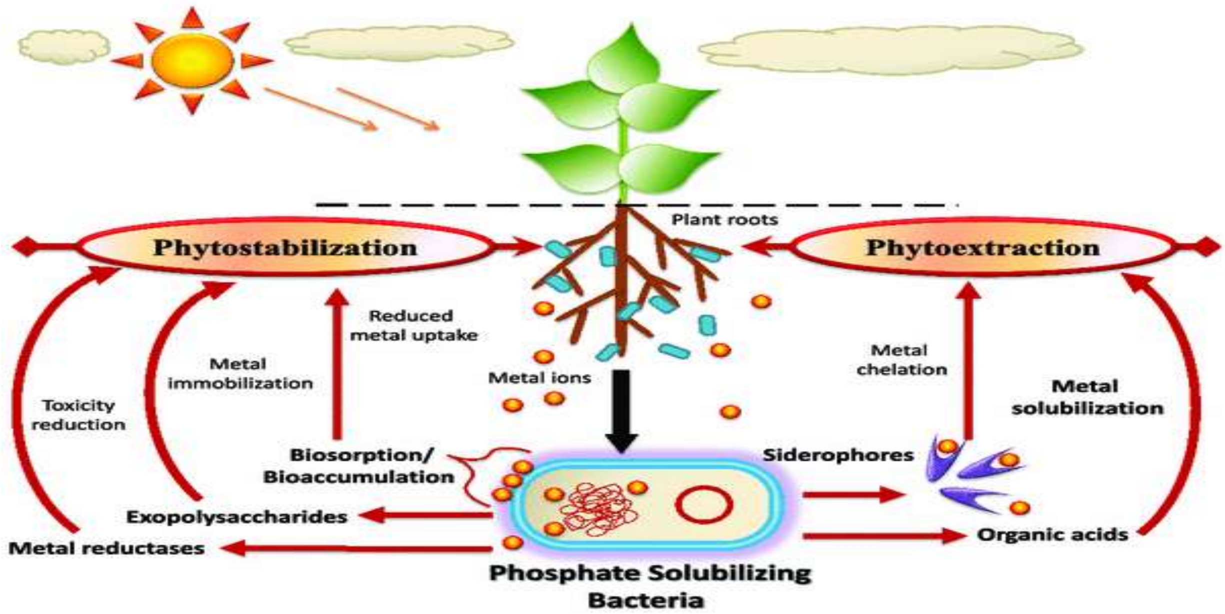

Fig: Role of Phosphate Solubilizing Bacteria

1. Production of Organic Acids: PSB secrete organic acids, such as gluconic, citric, and malic acids, which acidify the soil environment and break down insoluble phosphate

©2022 CPIJR | Volume 3 | Issue 3 | ISSN: 2583-1895
July-September-2024 | DOI: https://doi.org/10.5281/zenodo.14029535

compounds. The resulting decrease in soil pH helps release bound phosphates, thereby increasing the bioavailability of phosphorus for plant uptake (Rodríguez & Fraga, 1999).

2. Enzyme Secretion: PSB produce enzymes like phosphatases and phytases, which hydrolyze organic phosphorus compounds into inorganic phosphate, further enhancing phosphorus availability in the soil. These enzymes decompose complex organic phosphorus found in soil organic matter and mineral complexes, converting it into forms that plants can absorb (Khan et al., 2007).

3. Siderophore Production: PSB also release siderophores, which are compounds that chelate iron. By binding to iron, siderophores reduce the fixation of phosphorus with iron compounds, thus increasing the availability of free phosphorus for plant absorption (Vassilev et al., 2006). Several bacterial genera, including Pseudomonas, Bacillus, and Rhizobium, have demonstrated significant phosphate solubilizing potential. For instance, Pseudomonas and Bacillus species are known for their ability to produce organic acids and phosphatase enzymes, while Rhizobium plays a dual role in nitrogen fixation and phosphorus solubilization (Zaidi et al., 2009). In chickpea cultivation, PSB inoculation has been shown to enhance phosphorus availability, stimulate root development, and improve nitrogen fixation due to the symbiotic relationship between chickpeas and Rhizobium bacteria. This symbiosis results in increased biomass production, higher yields, and improved grain quality. Studies have reported that PSB inoculation in chickpea fields can increase phosphorus uptake and utilization, leading to better overall crop performance (Alori et al., 2017).

By utilizing PSB as a sustainable alternative to chemical phosphorus fertilizers, farmers can improve soil fertility, reduce environmental risks, and promote long-term agricultural sustainability.

4. Organic Amendments in Chickpea Cultivation

Organic amendments such as compost, farmyard manure (FYM), and vermicompost are widely recognized for their ability to enhance soil health and fertility, particularly in legume crops like chickpea. These amendments are rich in essential nutrients and organic matter, which improve soil structure, water retention, and promote microbial activity, including the activity of phosphate solubilizing bacteria (PSB). In addition to their nutrient content, organic amendments contribute to phosphorus cycling by providing a substrate that supports the growth and activity of soil microorganisms, facilitating the release of bound phosphorus for plant uptake.

Compost

Career Point International Journal of Research (CPIJR)
©2022 CPIJR | Volume 3 | Issue 3 | ISSN: 2583-1895
July-September-2024 | DOI: https://doi.org/10.5281/zenodo.14029535

Compost is a nutrient-rich organic material produced through the controlled aerobic decomposition of organic waste. It releases nutrients slowly over time, providing a steady supply of essential elements like nitrogen, phosphorus, and potassium throughout the growing season. The slow-release nature of compost ensures that nutrients are available when the plant needs them, reducing nutrient losses due to leaching or volatilization. Furthermore, compost improves soil texture and structure, enhancing root development, water retention, and aeration, which are crucial for the growth of chickpea plants (Ghosh et al., 2015). Studies have shown that the application of compost not only increases nutrient availability but also enhances the microbial diversity and activity in the soil, particularly the population of PSB (Kaur et al., 2017).

Vermicompost

Vermicompost is produced by the decomposition of organic matter with the help of earthworms, resulting in a highly nutritious organic fertilizer. Vermicompost is rich in phosphorus and other essential nutrients and has been shown to improve soil fertility and microbial activity significantly (Arancon et al., 2005). The presence of plant growth-promoting microorganisms, including PSB, in vermicompost enhances the solubilization of phosphorus and makes it more accessible to chickpea plants. Vermicompost has also been shown to increase the diversity of soil microbial communities, which further aids in nutrient cycling and promotes sustainable soil health (Sinha et al., 2010). In chickpea cultivation, vermicompost improves plant growth, nutrient uptake, and overall yield by providing both macro and micronutrients in a readily available form.

Farmyard Manure (FYM)

Farmyard manure (FYM) is a traditional organic amendment made from the decomposition of animal waste and bedding materials. FYM is a valuable source of nutrients, particularly phosphorus, and has long been used to improve soil structure, water-holding capacity, and nutrient content (Bhattacharyya et al., 2008). When combined with PSB, FYM enhances phosphorus availability by providing a rich organic substrate for microbial activity. The organic matter in FYM stimulates the growth of PSB and other beneficial microorganisms, which further facilitate the solubilization and mobilization of phosphorus in the soil (Sharma et al., 2013). Research indicates that the combined application of FYM and PSB leads to improved chickpea growth, nodulation, and higher yield (Bashan et al., 2013).

5. Synergy between Phosphate Solubilizing Bacteria (PSB) and Organic Amendments

The combined application of phosphate solubilizing bacteria (PSB) and organic amendments has been shown to significantly improve chickpea productivity compared to the use of either input alone. Organic amendments, such as compost, vermicompost, and farmyard manure (FYM), create a favorable environment for PSB by providing an abundant source of organic matter, which serves as both a substrate for microbial activity and a medium for nutrient cycling. In turn, PSB enhance the process of phosphorus solubilization and mineralization from organic sources, making it more accessible to chickpea plants. Several studies have demonstrated the benefits of this synergistic interaction in chickpea cultivation. When chickpeas are inoculated with PSB and supplemented with organic amendments, the following positive outcomes are typically observed:

Improved Phosphorus Uptake: PSB increase the availability of phosphorus by breaking down insoluble phosphorus compounds, while organic amendments supply additional nutrients, further promoting phosphorus uptake by plants.

Increased Root Biomass and Nodule Formation: The enhanced phosphorus availability and better soil structure from organic amendments support greater root growth and nodule development, which are essential for the plant's nutrient absorption and nitrogen-fixing capacity.

Enhanced Nitrogen Fixation: Better root growth, facilitated by the combined action of PSB and organic amendments, leads to improved interactions between chickpea roots and rhizobia, resulting in more efficient nitrogen fixation.

Higher Yield and Grain Quality: The overall improvement in nutrient uptake, root development, and nitrogen fixation translates into increased biomass, higher grain yield, and improved grain quality.

This synergistic combination not only boosts chickpea productivity but also enhances soil health by increasing microbial diversity and activity. This microbial stimulation leads to improved nutrient cycling, better soil structure, and long-term soil fertility, which are critical factors for sustainable agriculture. The use of PSB and organic amendments together creates a self-sustaining system that minimizes the need for chemical fertilizers while maintaining crop productivity and soil quality.

6. Environmental and Economic Benefits:

The integration of phosphate solubilizing bacteria (PSB) and organic amendments in chickpea cultivation offers substantial environmental and economic benefits. One of the key environmental advantages is the reduction in dependency on chemical fertilizers. Chemical phosphorus fertilizers contribute to environmental degradation, including water contamination and soil acidification. In contrast, the use of PSB and organic amendments reduces nutrient runoff and promotes more sustainable nutrient cycling within the soil. This practice not only preserves soil health but also minimizes the risk of soil degradation over time, leading to enhanced biodiversity and ecosystem stability.

Organic amendments such as compost and vermicompost, often sourced from farm or household waste, further enhance sustainability by recycling organic matter. The use of these materials reduces the need for synthetic inputs, helping farmers decrease their environmental footprint. Moreover, the combination of PSB and organic matter fosters healthier soil ecosystems by enhancing microbial activity, improving soil structure, and promoting long-term soil fertility.

Economically, the use of PSB and organic amendments reduces farmers' reliance on expensive chemical fertilizers, lowering production costs. Over time, this can increase profitability as improved soil health leads to sustained productivity and higher crop yields. Additionally, the adoption of organic practices enables farmers to access premium markets that favor sustainably produced crops, further enhancing economic returns.

7. Challenges and Future Prospects

Despite the considerable benefits of using PSB and organic amendments, several challenges impede their widespread adoption. One of the main challenges is the variability of PSB effectiveness across different soil types and environmental conditions. Not all soils possess the same capacity to support the activity of PSB, and further research is needed to identify the most effective bacterial strains for specific regions.

Another challenge lies in the availability and accessibility of organic amendments, especially for smallholder farmers. The production and transportation of organic materials such as compost and vermicompost can be labor-intensive and costly. Farmers may also lack sufficient knowledge about the proper application and management of PSB and organic amendments, underscoring the need for education and training programs. Looking ahead, future research should focus on optimizing the interaction between PSB and organic amendments for maximum efficiency. Identifying region-specific PSB strains and formulating strategies for more effective organic material use will be key to addressing phosphorus deficiencies in diverse agricultural settings. Additionally, efforts to scale up organic farming practices can be supported by government policies and incentives that encourage the use of sustainable inputs.

©2022 CPIJR | Volume 3 | Issue 3 | ISSN: 2583-1895
July-September-2024 | DOI: https://doi.org/10.5281/zenodo.14029535

8. Conclusion

Chickpea (Cicer arietinum L.) is an essential pulse crop that significantly contributes to food security, particularly in regions with limited agricultural resources. However, phosphorus deficiency in soils remains a critical challenge to maximizing chickpea productivity. The reliance on chemical fertilizers to address this issue is unsustainable, leading to environmental degradation and long-term soil health decline. The integration of phosphate solubilizing bacteria (PSB) and organic amendments offers a sustainable and effective solution to this problem. PSB improve phosphorus availability by converting insoluble phosphorus into forms that plants can readily absorb, while organic amendments such as compost, vermicompost, and farmyard manure enhance soil structure, microbial activity, and nutrient cycling. Together, these biological inputs create a synergistic effect that not only boosts phosphorus uptake, root development, and nitrogen fixation but also improves chickpea yield and soil health. Adopting these practices offers significant environmental and economic benefits. They reduce dependency on chemical fertilizers, minimize environmental pollution, and promote long-term soil fertility; all while lowering production costs for farmers. However, challenges such as variability in PSB effectiveness across different soils and limited availability of organic amendments must be addressed to scale up these practices.

References

1. Alori, E. T., Glick, B. R., & Babalola, O. O. (2017). Microbial phosphorus solubilization and its potential for use in sustainable agriculture. Frontiers in Microbiology, 8, 971.
2. Khan, M. S., Zaidi, A., & Wani, P. A. (2007). Role of phosphate-solubilizing microorganisms in sustainable agriculture - A review. *Agronomy for Sustainable Development, 27(1), 29–43.
3. Rodríguez, H., & Fraga, R. (1999). Phosphate solubilizing bacteria and their role in plant growth promotion. Biotechnology Advances, 17(4-5), 319–339.
4. Vassilev, N., Vassileva, M., & Fenice, M. (2006). Immobilized microbial solubilization of insoluble inorganic (rock) phosphates. Scientific World Journal, 6, 9–17.
5. Zaidi, A., Khan, M. S., Ahemad, M., & Oves, M. (2009). Plant growth promotion by phosphate solubilizing bacteria. Acta Microbiologica et Immunologica Hungarica, 56(3), 263–284.

6. Arancon, N. Q., Edwards, C. A., Bierman, P., Welch, C., & Metzger, J. D. (2005). Influence of vermicomposts on field strawberries: Part 2. Effects on soil microbiological and chemical properties. Bioresource Technology, 97(2), 831-840.
7. Bashan, Y., Kamnev, A. A., & de-Bashan, L. E. (2013). Tricalcium phosphate is inappropriate as a universal selection factor for isolating and testing phosphate-solubilizing bacteria that enhance plant growth: A proposal for an alternative procedure. Biology and Fertility of Soils, 49 (4), 465-479.
8. Bhattacharyya, R., Chandra, S., & Aggarwal, P. (2008). Long term farmyard manure application effects on properties of a silty clay loam soil under maize–wheat cropping system. Soil and Tillage Research, 98 (1), 133-140.
9. Ghosh, S., Majumdar, S., Saha, R., & Mandal, A. (2015). Effect of integrated nutrient management on soil fertility and productivity of chickpea in a semi-arid environment. Journal of Plant Nutrition, 38 (12), 1974-1987.
10. Kaur, G., Reddy, M. S., & Bawa, S. S. (2017). Microbial phosphate solubilization and its effect on plant growth promotion. Indian Journal of Experimental Biology, 55 (3), 189-200.
11. Bhattacharyya, R., Chandra, S., & Aggarwal, P. (2008). Long term farmyard manure application effects on properties of a silty clay loam soil under maize–wheat cropping system. Soil and Tillage Research, 98(1), 133-140.
12. Sharma, S., Sayyed, R. Z., Trivedi, M. H., & Gobi, T. A. (2013). Phosphate solubilizing microbes: sustainable approach for managing phosphorus deficiency in agricultural soils. Springer Plus, 2, 587.
13. Sinha, R. K., Heart, S., Agarwal, S., Asadi, R., & Carretero, E. (2010). Vermiculture and sustainable agriculture. American-Eurasian Journal of Agricultural & Environmental Sciences, 8(6), 763-793.
14. Bhattacharyya, R., Chandra, S., & Aggarwal, P. (2008). Long term farmyard manure application effects on properties of a silty clay loam soil under maize–wheat cropping system. Soil and Tillage Research, 98 (1), 133-140.
15. Ghosh, S., Majumdar, S., Saha, R., & Mandal, A. (2015). Effect of integrated nutrient management on soil fertility and productivity of chickpea in a semi-arid environment. Journal of Plant Nutrition, 38 (12), 1974-1987.

16. Sharma, S., Sayyed, R. Z., Trivedi, M. H., & Gobi, T. A. (2013). Phosphate solubilizing microbes: sustainable approach for managing phosphorus deficiency in agricultural soils. Springer Plus, 2, 587.
17. Ghosh, S., Majumdar, S., Saha, R., & Mandal, A. (2015). Effect of integrated nutrient management on soil fertility and productivity of chickpea in a semi-arid environment. Journal of Plant Nutrition, 38(12), 1974-1987.
18. Kaur, G., & Reddy, M. S. (2015). Effects of phosphate-solubilizing bacteria, rock phosphate, and chemical fertilizers on maize-wheat cropping cycle and economics. Pedosphere, 25(3), 428-437.
19. Sharma, A., Parihar, M., & Parihar, P. (2017). Organic farming and its impact on soil health and productivity in pulse crops: A review. Legume Research-An International Journal, 40(4), 621-630.
20. Richardson, A. E., & Simpson, R. J. (2011). Soil microorganisms mediating phosphorus availability. Plant Physiology, 156(3), 989-996.
21. Singh, B., & Rengel, Z. (2007). Phosphorus bioavailability and plant growth in soils amended with poultry manure and commercial fertilizers. Australian Journal of Soil Research, 45(1), 41-51.
22. Mishra, P. K., Bisht, S. C., Ruwari, P., & Joshi, G. K. (2010). Synergistic effects of phosphate solubilizing microorganisms and organic amendments on growth and productivity of chickpea. Applied Soil Ecology, 45(1), 319-326.
23. Bhattacharyya, P. N., & Jha, D. K. (2012). Plant growth-promoting rhizobacteria (PGPR): emergence in agriculture. World Journal of Microbiology and Biotechnology, 28(4), 1327-1350.

Career Point International Journal of Research (CPIJR)
©2022 CPIJR | Volume 3 | Issue 3 | ISSN: 2583-1895
July-September-2024 | DOI: https://doi.org/10.5281/zenodo.14029539

Effect of Crop Residue Management on Soil Health and Crop Performance

Munmun Choudhary [1], Rohitashv Nagar[2], Dr. Narendra Kumar Bhinda[3], Deepak Nagar[4]

School of Agricultural Sciences, Career Point University, Kota

[1]M.Sc. Agronomy Student, Department of Agronomy, School of Agricultural Sciences, Career Point University, Kota, Rajasthan, India Email: munmun.choudhary@gmail.com

[2,3,4] Assistant Professor, Department of Agronomy, School of Agricultural Sciences, Career Point University, Kota, Rajasthan, India Email: rohitashv.nagar@cpur.edu.in

Abstract

As global populations increase, the amount of crop residues generated annually continues to rise. Traditionally used for energy and animal feed, crop residues are now often treated as waste due to changes in living standards. Rich in nutrients and easily decomposed by microorganisms, crop residues offer significant potential for soil enrichment when managed properly. Returning crop residues to the soil instead of burning them is a sustainable practice that enhances soil health and reduces environmental damage. However, poor agricultural practices and industrial activities often degrade soil quality, and residues can aid in soil improvement and contamination remediation. While incorporating crop residues can improve soil texture, nutrient content, and microbial activity, it can also lead to negative effects such as pest infestations and increased methyl mercury levels in contaminated soils. This review examines the composition, nutrient content, and structural characteristics of crop residues, emphasizing their role in soil enhancement and contamination cleanup. A nuanced understanding of residue management is essential for promoting soil health and environmental sustainability.

Keywords: Crop Residues, Soil Quality, Soil Remediation, Heavy Metals.

Introduction

As the global population continues to grow, the quantity of crop residues generated each year increases. Historically, these residues were utilized as energy sources and animal feed. However, with economic development and rising living standards, they are now often regarded as agricultural waste. Crop residues, rich in nutrients and capable of decomposition by microorganisms, offer substantial potential for soil enrichment when properly managed. Rather than burning them, returning crop residues to the soil is recommended as a sustainable agricultural practice that enhances soil health and reduces environmental impact (Kumar *et al.* , 2020; Lal, 2005).

Declining soil quality is frequently the result of poor agricultural practices, such as continuous monocropping, overuse of chemical fertilizers, and excessive application of pesticides and herbicides (Zhang et al. , 2018). Additionally, human activities, including mining and industrial processes, can lead to soil contamination. Numerous studies have demonstrated that the incorporation of crop residues into the soil can improve its quality and even aid in the remediation of contaminated soils (Wang *et al.* , 2019; Liu *et al.* , 2016).

However, the benefits of returning crop residues to soil are not guaranteed in every case. For example, residue decomposition can sometimes promote pest infestations and plant diseases. In certain conditions, the application of rice straw may lead to the loss of dissolved organic carbon, potentially harming soil and groundwater quality. Furthermore, adding rice straw to mercury-contaminated soils has been shown to increase harmful methyl mercury levels in crops like wheat and rice (Zhu *et al.* , 2014). The outcomes of crop residue incorporation depend on various factors, including the type and quantity of residue, the methods of application, tillage intensity, fertilizer use, climate conditions, and soil characteristics (Singh *et al.* , 2021).

This review explores the composition, nutrient content, and physical structure of crop residues, focusing on their role in soil improvement and contamination cleanup. A clear understanding of these effects is crucial for ensuring that the use of crop residues in agricultural practices supports both soil health and environmental sustainability.

Characteristics of Crop Residues:

Composition: Crop residues, which are the plant remains left after harvesting, primarily consist of three main components: cellulose, hemicellulose, and lignin (Lal, 2005; Kumar *et al.* , 2020). Cellulose (40–50%): Cellulose is a biopolymer composed of glucose units linked together in long chains. These chains align in parallel to form strong microfibrils that make up the plant's cell walls. The high percentage of cellulose in crop residues gives them structural strength and resilience (Somerville *et al.* , 2004).

Hemicellulose (15–25%): Hemicellulose is more structurally complex than cellulose, consisting of a mixture of various sugars such as xylans, xyloglucans, arabinoxylans, and glucomannans. Unlike cellulose, hemicellulose is more easily broken down due to its

Career Point International Journal of Research (CPIJR)
©2022 CPIJR | Volume 3 | Issue 3 | ISSN: 2583-1895
July-September-2024 | DOI: https://doi.org/10.5281/zenodo.14029539

amorphous nature, playing a crucial role in the flexibility and hydration of plant cell walls (Gomes *et al.* , 2013).

Lignin (20–30%): Lignin is a phenolic polymer composed of three primary alcohols: p-coumaryl, coniferyl, and sinapyl alcohols. It cross-links cellulose and hemicellulose, forming a rigid and complex three-dimensional structure in the plant's cell walls. Lignin provides mechanical strength and resistance to microbial degradation, contributing to the durability of crop residues (Ralph *et al.* , 2004).

In simpler terms, crop residues consist of cellulose fibers, which are surrounded by hemicellulose and bound together by lignin. This combination results in a tough and stable structure that serves as a natural defense against environmental factors and decomposition.

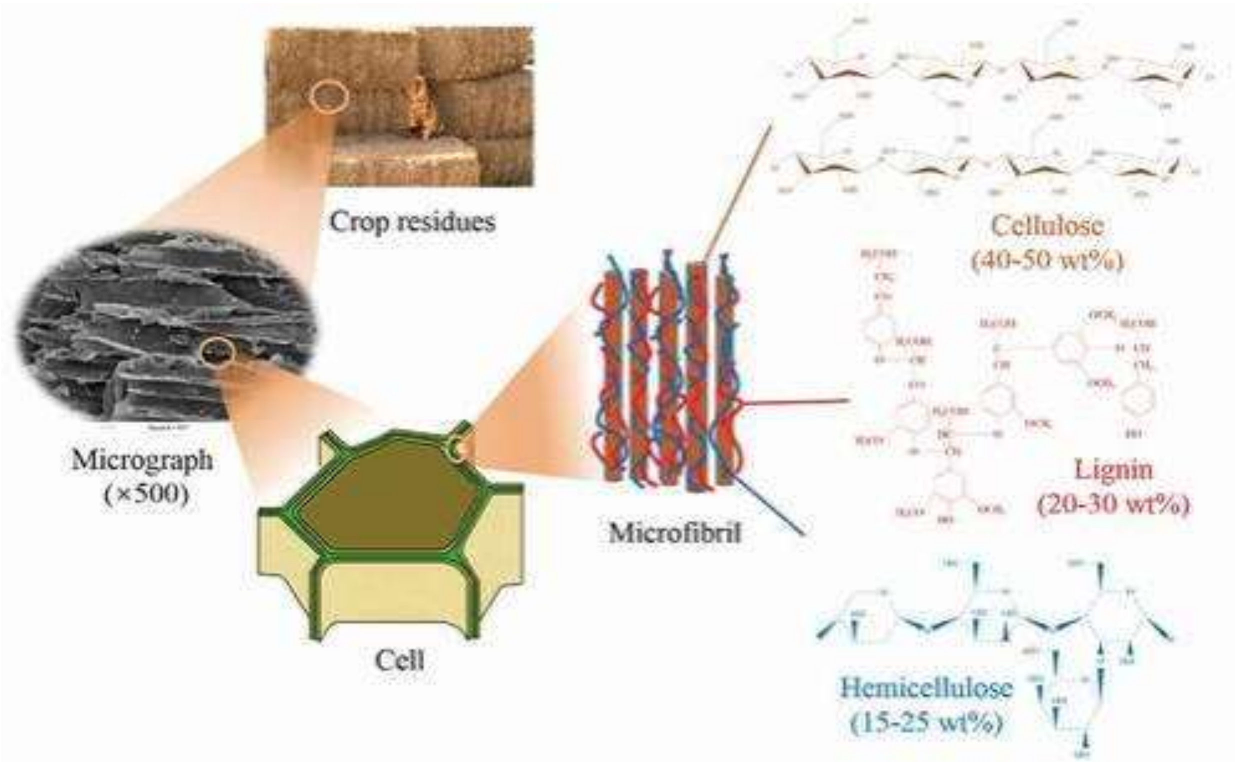

Figure.1. Structure and composition of crops

Nutrient content:

Crop residues are rich in nutrients essential for plant growth. They mainly contain carbon (40%-45%), nitrogen (0.6%-1%), phosphorus (0.45%-2%), potassium (14%-23%), and small amounts of other important minerals. These nutrients help balance soil nutrients and can improve the effectiveness of inorganic fertilizers.

The rate at which these nutrients are released into the soil depends on several factors:

Properties of the residues: The carbon-to-nitrogen (C/N) ratio and the chemical makeup of the residues influence how quickly they break down. For example, a C/N ratio greater than

25:1 usually means that nitrogen is temporarily locked up, while a lower ratio leads to faster nutrient release.

Climate: Warmer temperatures and proper soil moisture can speed up the decomposition of residues and the release of nitrogen.

Soil conditions: Factors like soil pH and water content also affect the breakdown and nutrient release.

Application method: Whether crop residues are directly added to the soil or applied indirectly can also impact how nutrients are released.In summary, crop residues not only add organic matter to the soil but also provide essential nutrients that can enhance soil fertility and support crop growth.

Physical structure:

Crop residues have a unique tubular structure with thick walls, making them lightweight. Their hollow structure is made up of cell walls with many small pores. These pores differ in size and arrangement, depending on the type of crop residue.

Rice straw: Inside rice straw, there are many vascular bundles, cavities, and other porous tissues. It has a relatively low surface area (0.77 m^2/g) and a small pore volume (0.0059 m^3/g).

Wheat straw: Wheat straw has a linear, multi-cavity structure that creates a complex network of connected pores. The average pore size is 13.90 nm, and it has a cumulative pore volume of 0.01 cm^3/g.

Corn stalks: Corn stalks have mostly nanometer-sized pores (5–100 nm). These small pores contribute to a large total surface area of 31.88 m^2/g and a high porosity of 73.33%.

Cotton stalks: Cotton stalks mainly consist of larger pores (macro-pores) and have a low surface area (1.95 m^2/g) with a total pore volume of 0.0115 m^3/g. In simple terms, different crop residues have different pore structures that affect their overall properties, such as how much surface area and pore volume they have, which can influence how they interact with soil and other materials.Bulk density measures how tightly packed crop residues are. This varies depending on the type of crop residue and how uniform they are.

Wheat straw: Has a very low bulk density because it has hollow stems and a lightweight outer layer.

Maize straw: Also has a low bulk density due to its loose structure.

Soybean straw and cotton stalks: Have higher bulk densities because they have solid stems and a more compact structure. In simpler terms, crop residues like wheat and maize are

©2022 CPIJR | Volume 3 | Issue 3 | ISSN: 2583-1895
July-September-2024 | DOI: https://doi.org/10.5281/zenodo.14029539

lighter and less tightly packed, while soybean and cotton residues are denser and more tightly packed.

Crop residues for soil improvement

Texture

Returning crop residues to the soil can greatly enhance the physical properties of the soil in various ways:

- **Soil Moisture Content**: Incorporating crop residues can help increase soil moisture by reducing surface runoff and evaporation and improving water infiltration and absorption. For instance, a study observed that covering soil with straw improved moisture content from 12.3% to 16.6% over two years (Chen *et al.* , 2019). However, initially, soil moisture may drop as residues and microorganisms absorb water, requiring timely irrigation to compact the soil and improve contact between residues and the soil (Zhang *et al.* , 2020).
- **Soil Bulk Density**: Bulk density refers to how compact the soil is. Adding crop residues can reduce bulk density, improving soil structure. One study found that incorporating maize and wheat straw reduced soil bulk density by 5.7% in the top 20 cm of soil over seven years and by 9.5% during a single growing season (Li *et al.* , 2018).
- **Soil Porosity**: This refers to the space between soil particles, which is essential for air and water movement. Crop residues can increase soil porosity. For example, wheat straw additions increased soil porosity by about 5% in various soil layers (Wang *et al.* , 2021). However, excessive porosity may hinder seed-to-soil contact, requiring proper watering and soil compaction.
- **Soil Aggregate Stability**: Soil aggregates are clusters of soil particles crucial for maintaining soil structure. Incorporating crop residues can increase both the size and stability of these aggregates, thereby enhancing soil's capacity to retain water and nutrients. For example, wheat straw additions improved aggregate stability, as indicated by the mean weight diameter (MWD) and geometric mean diameter (GMD), which reflect better soil structure (Yu *et al.* , 2020). In simpler terms, adding crop residues can improve soil moisture retention, reduce compaction, increase porosity, and enhance aggregate stability, promoting healthier and more productive soil.

Career Point International Journal of Research (CPIJR)
©2022 CPIJR | Volume 3 | Issue 3 | ISSN: 2583-1895
July-September-2024 | DOI: https://doi.org/10.5281/zenodo.14029539

pH and Cation Exchange Capacity (CEC)

- **Soil pH Changes**: Crop residues can influence soil pH, particularly in soils with low buffering capacity. In some cases, decayed crop residues increase soil pH, reducing acidity. A study reported that using decayed residues increased acidic soil pH by 55%-75% (Fan *et al.* , 2021). However, in practices like no-till farming or rotary tillage, adding straw reduced pH slightly, from 7.7 to 7.2 (Sun *et al.* , 2019). These effects can persist for over two years, depending on factors like residue type and nutrient cycling.
- **Cation Exchange Capacity (CEC)**: CEC measures a soil's ability to hold and exchange nutrients. Returning crop residues enhances organic matter, which increases CEC. For example, retaining 30% of crop residues raised CEC by 11.3% compared to retaining 15%, and by 27.32% compared to complete residue removal (Zhao *et al.* , 2020). Another study showed wheat residues increased CEC by 9.39% to 21.59% over five growing seasons (Huang *et al.* , 2022). In summary, crop residues can either raise or lower soil pH, and their management can significantly improve nutrient retention and exchange in the soil, supporting healthy plant growth.

Organic Carbon and Soil Nutrients: Decaying crop residues recycle vital nutrients, including organic carbon, nitrogen, phosphorus, and potassium.

- **Organic Carbon**: Crop residues contain around 40% organic carbon, which enhances soil stability through larger aggregates. For example, adding garlic stalks increased organic carbon content by 50% in two years (Liu *et al.* , 2021). Returning residues also mitigates carbon loss.
- **Nitrogen**: Nitrogen is essential for proteins and DNA synthesis in plants. The nitrogen in crop residues can be converted into ammonium (NH_4^+) and nitrate (NO_3^-), which are usable by plants. Incorporating straw and fertilizers increased available nitrogen by 64% in the top 20 cm of soil (Wang *et al.* , 2020). However, residues with a high carbon-to-nitrogen ratio may immobilize nitrogen, necessitating supplemental fertilizers.

- **Phosphorus**: Microorganisms decompose phosphorus in residues into plant-available forms. Long-term straw additions significantly boosted phosphorus use efficiency from 43% to 72% after 30 years (Li *et al.* , 2019).
- **Potassium**: Potassium is readily released from residues, replenishing soil levels. Garlic stalks and soybean residues have been shown to significantly increase potassium availability (Zhang *et al.* , 2019). In summary, returning crop residues enriches the soil with essential nutrients that improve plant growth and soil health over time.

Allelochemicals: Allelochemicals are bioactive compounds in crop residues that influence plant growth.

- **Phenolic Acids (Pas)**: These are well-known allelochemicals that can inhibit seed germination and seedling growth. For instance, lignin decomposition produces Pas, which can reduce weed seed germination by up to 100% at high concentrations (Zhou *et al.* , 2021).
- **Beneficial Effects**: Pas have antifungal properties and can reduce weed growth and stabilize soil aggregates, enhancing soil structure (Jiang *et al.* , 2019). Fertilization can help manage the release of harmful allelochemicals, ensuring residues benefit the soil and subsequent crops.

Microbial Activity: Crop residues support soil microbial communities by enhancing organic matter.

- **Microbial Diversity**: Retaining sugarcane straw for months increased fungal diversity in topsoil (Xu et al. , 2020). However, different residues have varying effects. For instance, corn straw reduced fungal diversity compared to wheat straw (Su *et al.* , 2021).
- **Long-Term Effects**: A 30-year study showed that combining rice straw with fertilizers improved fungal diversity without affecting overall bacterial counts (Zhao *et al.* , 2020).

In summary, crop residues boost beneficial soil microbes, but their impact depends on the type of residue and its management.

Conclusion

Crop residues are rich in carbon and contain essential nutrients like nitrogen, phosphorus, potassium, and trace elements. Adding these residues to the soil is a sustainable way to improve soil quality without disrupting its natural balance. As crop residues break down, they increase the levels of organic carbon and available nutrients like phosphorus and potassium in the soil, which benefits both microorganisms and crops. Additionally, crop residues help improve soil moisture, structure, and porosity. While some chemicals in crop residues can negatively affect crop growth, proper management of residue returning can minimize these effects. However, the impact of crop residues on soil pH and heavy metals is mixed, with some studies showing that residues can reduce the availability of certain heavy metals under specific conditions. Crop residues can also reduce the bioavailability of some soil pollutants, help control certain soil-borne diseases, and improve saline-alkaline soils.

To maximize the benefits of crop residue returning, it’s important to match the nutrient release from residues with the nutrient needs of the crops. Combining crop residues with partial nitrogen fertilizers, straw decomposition agents, and lime can enhance the breakdown of residues by boosting soil microbial activity. However, factors like soil conditions, climate, and the quality of crop residues can affect the decomposition process and may sometimes cause negative effects. Therefore, a systematic approach to crop residue returning is needed to ensure long-term soil health.

References:

1. Kumar, V., *et al.* (2020). Sustainable management of crop residues in agriculture: A global perspective. Agriculture, Ecosystems & Environment, 287.
2. Lal, R. (2005). World crop residues production and implications of its use as a biofuel. Environment International, 31(4), 575–584.
3. Liu, J., *et al.* (2016). Crop residues for remediation of contaminated soils. Environmental Science & Technology, 50(13), 7156–7164.
4. Singh, R., *et al.* (2021). The role of crop residues in sustainable soil management. Soil Biology & Biochemistry, 160.
5. Wang, X., *et al.* (2019). Crop residue management for sustainable agriculture. Journal of Environmental Management, 233, 146–157.
6. Zhang, Y., *et al.* (2018). Effects of continuous cropping on soil microbial community diversity and nutrient cycling. Agronomy, 8(6), 92.

7. Zhu, J., *et al.* (2014). Impact of rice straw on methyl mercury accumulation in contaminated soils. Journal of Hazardous Materials, 280, 536–544.

8. Chen, Y., *et al.* (2019). Effects of straw mulching on soil moisture and temperature in dryland areas. Agricultural Water Management, 213, 216–225.

9. Fan, R., *et al.* (2021). Impact of decayed crop residues on acidic soils. Soil Science Society of America Journal, 85(2), 342-355.

10. Gomes, G. D., *et al.* (2013). Hemicellulose: A sustainable raw material for biofuels and bioproducts. Renewable and Sustainable Energy Reviews, 26, 164–182.

11. Huang, Y., *et al.* (2022). Effects of wheat residue return on cation exchange capacity in soil. Soil and Tillage Research, 215.

12. Jiang, X., *et al.* (2019). Role of allelochemicals in improving soil structure. Plant and Soil, 435, 67–78.

13. Kumar, V., *et al.* (2020). Sustainable management of crop residues in agriculture: A global perspective. Agriculture, Ecosystems & Environment, 287.

14. Lal, R. (2005). World crop residues production and implications of its use as a biofuel. Environment International, 31(4), 575–584.

15. Li, S., *et al.* (2018). Long-term effects of straw incorporation on soil bulk density. Soil and Tillage Research, 184, 289–297.

16. Liu, H., *et al.* (2021). Garlic stalk addition boosts soil organic carbon. Environmental Science and Pollution Research, 28(13), 16024-16033.

17. Ralph, J., *et al.* (2004). Lignins: Natural polymers from oxidative coupling of 4-hydroxyphenylpropanoids. Phytochemistry Reviews, 3(1), 29–60.

18. Somerville, C., et al. (2004). Toward a systems approach to understanding plant cell walls. Science, 306(5705), 2206–2211.

19. Su, J., *et al.* (2021). Effects of crop residue return on soil microbial diversity. Frontiers in Microbiology, 12.

20. Sun, H., *et al.* (2019). Impact of no-till practices on soil pH with straw cover. Agronomy Journal, 111(3), 786-794.

21. Wang, Q., *et al.* (2021). Effects of crop residues on soil porosity. Geoderma, 387, 114860.

22. Yu, S., *et al.* (2020). Influence of crop residues on soil aggregate stability. Journal of Agricultural Science, 158(5), 329-340.

23. Zhao, B., *et al.* (2020). Long-term effects of crop residue management on microbial diversity. Soil Biology & Biochemistry, 144.

Career Point International Journal of Research (CPIJR)
©2022 CPIJR | Volume 3 | Issue 3 | ISSN: 2583-1895
July-September-2024 | DOI: https://doi.org/10.5281/zenodo.14029546

Impact of Land Use Changes on Soil Properties and Functionality

Parmod Kumar [1], Rohitashv Nagar[2], P. C. Choudhary[3], Dr. Narendra Kumar Bhinda[4], Deepak Nagar[5]

School of Agricultural Sciences, Career Point University, Kota

[1]M.Sc. Agronomy Student, Department of Agronomy, School of Agricultural Sciences, Career Point University, Kota, Rajasthan, India Email: parmod.kumar@gmail.com

[2,3,4,5] Assistant Professor, Department of Agronomy, School of Agricultural Sciences, Career Point University, Kota, Rajasthan, India Email: rohitashv.nagar@cpur.edu.in

Abstract

Land use change involves the transformation of natural landscapes through human activities, altering their physical and ecological characteristics. This process includes converting natural environments like forests into agricultural or urban areas, which can lead to soil degradation through mechanisms such as surface runoff, pollution, and erosion. Despite these challenges, agricultural and woodland areas within urban and peri-urban regions continue to provide essential services, including food production, water supply, and climate regulation. The drivers of land use change are complex and interconnected, involving economic development, population growth, technological advancements, and policy and governance factors. Analysis of land use from 2001 to 2021 reveals significant shifts: vegetation and water-covered areas have decreased, while settlements, arid lands, and agricultural areas have expanded. Land use change impacts soil functionality by degrading soil quality and reducing essential ecosystem services. Factors such as decreased soil organic matter, nutrient depletion, increased erosion, altered soil structure, and changes in soil pH highlight the need for sustainable land use policies and restoration practices. These impacts are evident in soil composition, nutrient availability, porosity, water holding capacity, and overall soil health. Groundwater quality also suffers from poor land management, with issues such as salinization, nitrate pollution, contamination by agricultural chemicals, depletion, and seawater intrusion. Soil biodiversity is threatened by habitat loss, pollution, and soil degradation, emphasizing the need for sustainable practices to preserve biodiversity and soil health. In conclusion, land use change significantly affects soil properties and functionality, leading to reduced soil fertility, increased erosion, and overall degradation. Effective land management and restoration practices are vital for maintaining soil productivity and ensuring the sustainability of natural resources and ecosystems.

Key Words: Land, Quality, Soil Properties and Functionality

Introduction:

Land use change refers to the transformation of natural landscapes by human activities, altering their physical characteristics and ecological functions. This process includes the conversion of natural environments, such as forests, into agricultural land or urban areas. Land-use change often leads to soil degradation through surface runoff, pollution, and erosion. However, in urban and peri-urban regions, areas dedicated to agriculture and woodlands still play crucial roles in providing essential services like food production, water supply, and climate regulation.

Land-use change has a significant impact on soil properties and soil organic carbon levels, particularly in intensively managed areas like croplands and vineyards. Practices such as tillage, pesticide application, and the use of fertilizers contribute to the degradation of soil quality. As a global issue, land-use change (LUC) affects agriculture, soil properties, ecosystems, and the broader environment, including atmospheric composition (Hasan *et al*., 2020; Han and Zhu, 2020; Newbold *et al*., 2015). Intensively cultivated regions may see a reduction in the soil's ability to provide ecosystem services, such as carbon sequestration and flood mitigation.

Key dynamic soil properties such as soil organic matter (SOM), cation exchange capacity (CEC), total nitrogen (TN), pH, and texture are sensitive to land use practices. These properties provide valuable insights into important soil processes like nutrient cycling, decomposition, and SOM formation, which are critical for maintaining soil productivity (Mandal *et al*., 2007).

Causes of Land Use Change

Land use change is driven by a range of complex, interconnected factors, including human, economic, and environmental influences. A deeper understanding of these causes highlights the multifaceted nature of such changes:

- **Economic Development**: Activities like mining, agriculture, and construction often require the transformation of natural habitats into industrial, agricultural, or urban spaces.
- **Population Growth**: As populations expand, there is an increasing demand for housing, food, and infrastructure, which drives the conversion of natural landscapes into urban or agricultural areas.
- **Technological Advancement**: Innovations in farming, construction, and energy production can intensify land use, frequently at the expense of natural ecosystems.
- **Policy and Governance**: Government policies, zoning regulations, and property rights play a critical role in determining how land is used and the extent of land use change.

Land Use Changes (2001–2021)

An analysis of land use from 2001 to 2021, based on classified images, shows significant shifts. Vegetation and water-covered areas have decreased, while settlements, arid lands, and agricultural areas have expanded. Specifically:

- Water-bodies decreased by **75.93%**.
- Vegetation-covered land decreased by **87.77%**.
- Agricultural land increased from **838.88 km²** to **1254.25 km²**.
- Settlement areas grew from **63.29 km²** to **346.12 km²**.
- Arid land expanded from **465.25 km²** to **584.96 km²**.

Much of the previously vegetated land has been converted for agricultural and settlement use, driven largely by urban expansion and population growth.

Impact of Land Use Change on Soil Properties and Functionality

Land-use change, particularly through deforestation and soil disturbance, is a major contributor to soil quality degradation and greenhouse gas emissions. It affects soil's physical and chemical properties, leading to diminished soil quality and the loss of carbon stocks. Various global studies have explored land-use change management strategies that can restore soil carbon and microbial biomass. However, such analyses in the Indian context remain limited.

Career Point International Journal of Research (CPIJR)
©2022 CPIJR | Volume 3 | Issue 3 | ISSN: 2583-1895
July-September-2024 | DOI: https://doi.org/10.5281/zenodo.14029546

The overall impact of land-use and land-cover changes has led to soil degradation, emphasizing the need for appropriate land use policies and restoration practices to preserve soil productivity.

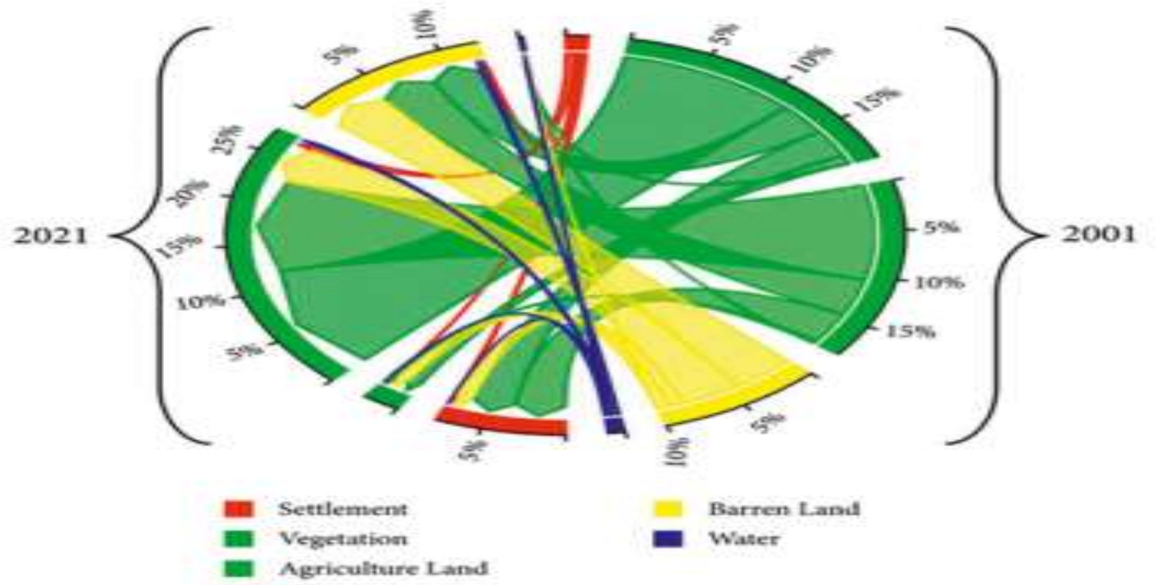

Fig: No-1 Impact of Land Use Change on Soil Properties and Functionality.

Impact of Land Use Change on Soil Properties:

Land use change significantly affects various soil properties in multiple ways, including:

Soil Composition:

Soil is a complex material composed of five key components:

Minerals: Derived from the breakdown of rocks, minerals are classified into three size groups—sand, silt, and clay. The relative amounts of these particles determine the soil's texture.

Organic Matter: Composed of decayed plant and animal matter, as well as microbial tissues, this component is crucial for soil fertility.

Water: Absorbed from the atmosphere and soil reactions, water plays an essential role in supporting plant life.

Air: Soil air is necessary for the respiration of soil organisms and plant roots, and it is supplied through both atmospheric exchange and soil reactions.

Living Organisms: Soil hosts a wide variety of life, from large organisms like earthworms and insects to microscopic bacteria and fungi.

Soil pH

Soil pH, which affects nutrient availability and plant growth, is strongly influenced by land use and management practices. For instance:

Natural forests typically have a slightly higher pH compared to cultivated and grazing lands.

Soils under orchards and block plantations tend to have lower pH compared to agricultural crops or silviagri systems. This is likely due to the accumulation of organic litter, which becomes acidic as it decomposes. Over time, converting forest or grassland to cropland can cause a significant drop in soil pH. This change is driven by the loss of organic matter, the depletion of soil minerals during crop harvests, and surface erosion. Additionally, the use of nitrogen and sulfur-based fertilizers can further lower pH levels, making soils more acidic.

Soil Nutrient Availability

Micronutrients in the soil are most readily available at the surface and their concentration decreases with depth. Higher cation exchange capacity (CEC), which is crucial for nutrient retention, is commonly observed in silviagri systems due to the presence of organic matter and specific types of clay particles. The amount and type of clay significantly influence CEC across various land use systems (Tufa *et al.*, 2019). Conversely, agricultural crops tend to have lower CEC, primarily due to reduced organic matter caused by intensive farming practices (Bhople and Sharma, 2020).

Nutrient availability is closely linked to soil pH, with essential plant nutrients classified as macronutrients and micronutrients based on plant needs. Macronutrients such as nitrogen, calcium, potassium, magnesium, and sulfur are most accessible in soils with a pH of 6.5–8, while micronutrients are typically available in a slightly more acidic range of pH 5–7. Outside of these optimal pH ranges, nutrient availability decreases, potentially limiting plant growth.

Soil Porosity and Water Holding Capacity

Intensive agricultural soils, including vegetable gardens, paddy fields, and tea gardens, tend to have higher porosity and water-holding capacity compared to other land types. Soil porosity the proportion of non-solid space within the total volume of soil is vital for plant growth, as it enables the movement of water, air, and nutrients.

Land use changes, such as converting grassland or shrubland to cropland, often reduce soil infiltration rates, making the soil less capable of absorbing water. This can negatively affect water availability and plant health over time.

Soil Degradation

Land use changes can accelerate soil degradation, notably through increased soil erosion. Erosion not only strips the land of fertile topsoil but also contributes to pollution by introducing sediment into rivers and streams, harming aquatic ecosystems. Eroded land is also less effective at retaining water, exacerbating flooding risks. Projections of future soil erosion rates rely heavily on models that factor in rainfall erosivity, land use changes, and the impact of policies on soil conservation. Recent developments, such as the Rainfall Erosivity Database at European Scale (REDES), offer valuable insights for predicting future rainfall-related erosion risks under different climate scenarios. Adopting sustainable land use practices is essential to mitigating soil erosion, preventing degradation, and avoiding the loss of valuable land to desertification.

Groundwater Quality

Poor land management and inappropriate land use practices can have lasting impacts on groundwater quality, leading to several chronic issues:

- **Salinization**: Groundwater salinity can increase due to obstructions in drainage systems or salt discharge. Poor irrigation management, which leads to excessive water stagnation, can be a major contributor to this issue.
- **Nitrate Pollution**: Agricultural activities, especially the extensive use of nitrogen-based fertilizers and tillage, can introduce large amounts of nitrates into groundwater, posing health risks and environmental hazards.
- **Contamination by Agricultural Chemicals**: Pesticides and herbicides used in farming can leach into groundwater, depending on their mobility and interaction with soil particles. This contamination poses risks to both human health and aquatic ecosystems.
- **Groundwater Depletion**: Rapid urbanization, increased industrialization, and intensive agricultural activities put significant pressure on groundwater resources, often leading to depletion over time.

Career Point International Journal of Research (CPIJR)
©2022 CPIJR | Volume 3 | Issue 3 | ISSN: 2583-1895
July-September-2024 | DOI: https://doi.org/10.5281/zenodo.14029546

- **Soil and Water Salinization**: The expansion of irrigated agricultural areas can result in the salinization of both soil and water, degrading their quality and limiting agricultural productivity.
- **Seawater Intrusion**: In coastal areas, over-extraction of groundwater for irrigation or other uses can lead to seawater intrusion, where saltwater contaminates freshwater aquifers.

Land use changes can influence groundwater quality by altering water demand, recharge rates, and the flow of contaminants into aquifers.

Soil Biodiversity

Land use changes significantly affect soil biodiversity, which includes the variety of plants, animals, and microorganisms within the soil. Sustainable agriculture is critical for preserving soil biodiversity, as soil quality and fertility can rapidly decline due to factors such as intensive cultivation, leaching, and erosion (Kiflu and Beyene, 2013). Key threats to biodiversity from land use changes include:

- **Habitat Loss**: Conversion of natural habitats into agricultural or urban land reduces their size and fragments ecosystems, which can lead to the extinction of species.
- **Pollution**: Excessive use of agrochemicals, such as pesticides, herbicides, and fertilizers, can damage ecosystems by harming pollinators, birds, and aquatic life.
- **Soil Degradation**: Hard surfaces from urbanization reduce rainwater infiltration, which impacts groundwater recharge and disrupts soil health.
- **Noise Pollution**: Urbanization and industrial activities contribute to increased noise levels, affecting both wildlife and human populations.

Impact of Land Use Change on Soil Functionality

Land use change impacts the environment, human health, and the ability to manage soil functionality in several ways:

- **Agricultural Profitability**: As land is converted from agricultural use to residential or industrial purposes, farmers face increased pressure on land availability, leading to reduced profitability. Higher operational and variable costs also contribute to this challenge.

CAREER POINT INTERNATIONAL JOURNAL OF RESEARCH
Career Point International Journal of Research (CPIJR)
©2022 CPIJR | Volume 3 | Issue 3 | ISSN: 2583-1895
July-September-2024 | DOI: https://doi.org/10.5281/zenodo.14029546

- **Ecosystem Services**: Changes in land use affect the ecosystem services provided by soil, such as supporting (nutrient cycling), provisioning (food and water), regulating (climate control), and cultural (recreational) services.
- **Management Practices**: Sustainable agricultural practices like cover cropping and reduced tillage can help mitigate the negative impacts of land use changes on soil health.
- **Regional Variations**: The impact of land use change on soil properties and ecosystem services varies by region, depending on climate and geographical factors.

Soil Ecosystems and Climate Change

Land use changes can have direct effects on soil ecosystems, including the biodiversity of organisms that support essential soil functions. These changes can also influence broader environmental processes:

- **Soil Ecosystems**: Land use conversion can disrupt the activities of "ecosystem engineers," such as earthworms and microbes that maintain soil structure and fertility.
- **Climate Change**: Land use changes, such as deforestation and conversion to agriculture, contribute to climate change by reducing carbon sequestration and increasing greenhouse gas emissions.
- **Natural Resources**: Altering land use can deplete valuable natural resources, such as water and fertile soil, which are essential for long-term sustainability.
- **Biodiversity**: Changes in land use can negatively impact biodiversity, causing species loss and reducing ecosystem resilience.
- **Ecological Balance**: Land use changes can disrupt ecological balance and sustainability by altering water cycles, nutrient flows, and habitat structures.

Conclusion:

Land use change, driven by human activities such as agriculture, urbanization, and economic development, has profound impacts on natural landscapes, soil properties, and ecological functions. The conversion of forests and other natural environments into agricultural or urban areas often leads to soil degradation through mechanisms like erosion, pollution, and surface runoff. These changes can reduce soil organic carbon levels and compromise the soil's ability to provide essential ecosystem services, such as carbon sequestration and flood mitigation.

The analysis of land use shifts from 2001 to 2021 highlights significant reductions in vegetation and water bodies, alongside expansions in agricultural, settlement, and arid areas. This transformation has led to notable soil quality issues, including decreased organic matter, altered soil pH, reduced nutrient availability, and increased erosion. These changes not only impact soil productivity but also affect groundwater quality, soil biodiversity, and broader ecosystem functions. Addressing the challenges posed by land use change requires a multifaceted approach that includes sustainable land management practices, restoration of degraded areas, and the implementation of policies that balance development with environmental preservation. Effective strategies must focus on maintaining soil health, protecting biodiversity, and ensuring the long-term sustainability of natural resources. By adopting these measures, we can mitigate the negative effects of land use change and support resilient ecosystems and productive agricultural systems.

References:

1. Bezak, N.; Ballabio, C.; Mikoš, M.; Petan, S.; Borrelli, P.; Panagos, P. Reconstruction of past rainfall erosivity and trend detection based on the REDES database and reanalysis rainfall. J. Hydrol. 2020, 590, 125372, doi:10.1016/j.jhydrol.2020.125372.

2. Bhavya VP, Kumar A, Kiran SK, Alur A, Shivakumar KM, Shivanna M. Effect of different cropping system on important soil enzyme activity, organic carbon and microbial activity with different depth.Int J CurrMicrobiol App Sci 2018;7:315-322.

3. Bhople BS, Sharma S. Seasonal variation of rhizospheric soil properties under different land use systems at lower Shivalik foothills of Punjab, India. Agroforestry Systems 2020;94(5):1959-1976

4. Black CA. Methods of soil analysis. Part 1 Physical and mineralogical properties, American Society of Agronomy, No: 9. Madison, WI, USA 1965.

5. Chapman HD. Cation exchange capacity. In: Methods of Soil Analysis. Part II, Black, C.A. (Ed.). Agronomy No.9. American Society of Agronomy, Madison, Wisconsin, USA 1965, 891-901.

6. Doran JW, Safley M. Defining and assessing soil health and sustainable productivity. In: Pankhurst CE, Doube BM, Gupta VVSR (eds) Biological indicators of soil health. CAB International, New York 1997, 1-28

7. Garcia-Gil JC, Plaza C, Soler-Rovira P, Polo A. Longterm effects of municipal solid waste compost application on soil enzyme activities and microbial biomass. Soil BiolBiochem 2000;32:1907-1913

8. Iwara AI, Ewa EE, Ogundele FO, Adeyemi JA, Otu CA. Ameliorating effects of palm oil mill effluent on the physical and chemical properties of soil in Ugep, Cross River State, South-Southern Nigeria. International Journal of Applied Science and Technology 2011; 1(5):106-112.

9. Jackson ML. Soil chemical analysis. Prentice Hall India Pvt. Ltd., New Delhi 1973, 498.

10. Kiflu A, Beyene S. Effects of different land use systems on selected soil properties in South Ethiopia. Journal of Soil Science and Environment Management 2013;4(5):100-107

11. Mandal A, Patra AK, Singh D, Swarup A, Masto RE. Effect of long-term application of manure and fertilizer on biological and biochemical activities in soil during crop development stages. Bioresource Technology 2007; 98: 35853592.

12. Maqbool M, Rasool R, Ramzan S. Soil physico-chemical properties as impacted by different land use systems in district Ganderbal, Jammu and Kashmir: India. International Journal of Chemical Studies 2017; 5(4):832840.

13. Olsen SR, Cole CU, Watanabe FS, Deen LA. Estimation of Available Phosphorus in Soil by Extracting with Sodium Bicarbonate; U.S. Government Printing Office: Washington, DCUSDA Circ 1954, 939

14. Pandey CB, Singh AK, Sharma DK. Soil properties under Acacia nilotica trees in a traditional agroforestry system in central India.AgroforSyst 2000;49:53-61.

15. Panagos, P.; Ballabio, C.; Meusburger, K.; Spinoni, J.; Alewell, C.; Borrelli, P. Towards estimates of future rainfall erosivity in Europe based on REDES and WorldClim datasets. J. Hydrol. 2017, 548, 251–262, doi:10.1016/j.jhydrol.2017.03.006.

16. Reza SK, Baruah U, Nath DJ, Sarkar D, Gogoi D. Microbial biomass and enzyme activity in relation to shifting cultivation and horticultural practices in humid subtropical North-Eastern India 2014.

17. Stefanidis, S.; Alexandridis, V.; Chatzichristaki, C.; Stefanidis, P. Assessing soil loss by water erosion in a typical Mediterranean ecosystem of northern Greece under current and future rainfall erosivity. Water 2021, 13, 2002, doi:10.3390/w13152002.

18. Selassie YG, Ayanna G. Effects of different land use systems on selected physico-chemical properties of soils in Northwestern Ethiopia. Journal of agricultural science 2013;5(4):112.

19. Subbiah BV, Asija GL. A rapid procedure for the determination of available nitrogen in soils. Current Science 1956; 25:259-260

20. Takele L, Chimdi A, Abebaw A. Dynamics of Soil fertility as ınfluenced by different land use systems and soil depth in West Showa Zone, Gindeberet District, Ethiopia. Agriculture, Forestry and Fisheries 2014; 3(6):489-494.

21. Tufa M, Melese A, Tena W. Effects of land use types on selected soil physical and chemical properties: the case of Kuyu District, Ethiopia. Eurasian Journal of Soil Science 2019;8(2):94-109.

22. Walkley A, Black CA. Estimation of organic carbon by chromic acid titration method. Soil Science 1934; 37:29- 38

CAREER POINT INTERNATIONAL JOURNAL OF RESEARCH
Career Point International Journal of Research (CPIJR)
©2022 CPIJR | Volume 3 | Issue 3 | ISSN: 2583-1895
July-September-2024 | DOI: https://doi.org/10.5281/zenodo.14029549

Yoga as an Integrative Therapy for Chronic Disease Management

Durgesh Nandan Verma[1], Priyanka Kumari[2], Sonal Joshi[3]
(PhD Scholar), Department of Social Studies, Dr. K. N. Modi University, Newai, Rajasthan
MA Yoga, Department of Social Studies, Dr. K. N. Modi University, Newai, Rajasthan
D pharmacy, School of Pharmaceutical Studies, Dr. K. N. Modi University, Newai, Rajasthan
Corresponding author: durgeshnandan.yogi@gmail.com, priyankabagdi32@gmail.com, joshisonal1029@gmail.com

Abstract

Yoga, originating from ancient India, is an integrative practice that combines physical postures, breathing techniques, and meditation to foster holistic well-being. This article delves into the types, classifications, and therapeutic benefits of yoga in the prevention and management of chronic diseases such as hypertension, diabetes, anxiety, and depression. Different forms of yoga—such as Hatha, Kundalini, Ashtanga, and Restorative—are examined for their unique physiological and psychological benefits. As a complementary therapy, yoga addresses both physical and mental health, uniquely engaging the mind-body connection to support balanced, sustainable wellness. Evidence suggests yoga improves cardiovascular, respiratory, immune, and musculoskeletal health, while also enhancing mental resilience. This review highlights yoga's role in reducing inflammation, balancing neuroendocrine functions, and supporting immune health. With increasing integration into healthcare, yoga presents a cost-effective, accessible approach to disease prevention and holistic patient care, underscoring its growing importance in modern therapeutic frameworks.

Keywords: Yoga, chronic disease management, holistic health, therapeutic benefits, mind-body integration.

1. Introduction

Yoga, an ancient practice originating in India over 5,000 years ago, has evolved from a spiritual discipline to a widely recognized approach for achieving holistic well-being. Traditionally, yoga was practiced to harmonize the mind, body, and spirit, fostering a balanced and centered life. The word "yoga" itself is derived from the Sanskrit root “yuj,” meaning to unite or join, symbolizing the integration of individual consciousness with universal consciousness. Initially, yoga was part of the broader philosophical and spiritual traditions in Hinduism, Jainism, and Buddhism, where it was revered as a path toward enlightenment and self-realization (1,2).

In recent decades, the perception of yoga has shifted significantly as scientific and medical communities have started to examine its diverse benefits. This transition, supported by an increasing body of research, has brought a new understanding of yoga's impact on physical, mental, and emotional health. Contemporary yoga integrates physical postures (asanas), controlled breathing techniques (pranayama), and meditative practices, making it accessible to people across cultures and age groups (2,3).

Studies suggest that regular yoga practice offers both preventive and therapeutic benefits, especially in managing chronic lifestyle-related illnesses. These conditions—such as hypertension, diabetes, anxiety, and depression—have become increasingly common in modern society due to sedentary lifestyles, stress, and unhealthy dietary habits. Unlike conventional physical exercise, yoga's benefits extend beyond the musculoskeletal system, positively influencing the autonomic nervous system, endocrine system, and immune function, which are critical in maintaining overall health. By reducing stress hormones and promoting relaxation, yoga fosters mental clarity and emotional resilience, creating a foundation for improved quality of life (3).

This article explores the various types of yoga, including Hatha, Kundalini, Ashtanga, Vinyasa, Iyengar, and Restorative, examining their unique techniques and therapeutic applications. Additionally, it categorizes yoga practices based on their physical, mental, spiritual, and service-oriented goals, which further highlights its adaptability to different needs and wellness objectives. Through this comprehensive analysis, the article aims to elucidate how yoga can serve as a preventive and therapeutic approach to modern health challenges, presenting a compelling case for its integration into lifestyle medicine and healthcare (1-4).

2. Objectives

- To Investigate various forms and classifications of yoga.
- To examine the scientific basis of yoga's benefits in disease prevention and management.
- To review yoga's role as an adjunctive therapy for chronic and lifestyle-related diseases.

3. Types and Classification of Yoga

A. Types of Yoga (5-8)

Career Point International Journal of Research (CPIJR)
©2022 CPIJR | Volume 3 | Issue 3 | ISSN: 2583-1895
July-September-2024 | DOI: https://doi.org/10.5281/zenodo.14029549

- Hatha Yoga: Focuses on physical postures (asanas) and breathing techniques (pranayama) to improve flexibility, strength, and mental calmness.

Figure 1: Hatha Yoga

- Kundalini Yoga: Uses dynamic breathing, chanting, and meditation to awaken energy centers, called chakras, in the body.
- Ashtanga Yoga: A physically demanding style involving synchronized breath and movement in a sequence of poses, promoting cardiovascular health.
- Vinyasa Yoga: Characterized by a flow of movements, integrating breath with posture changes to improve circulation and focus.
- Iyengar Yoga: Emphasizes precision in alignment and incorporates props to achieve therapeutic effects.
- Bikram Yoga: Involves a series of 26 postures in a heated room, promoting detoxification and flexibility.
- Restorative Yoga: A gentle practice using props for support, encouraging relaxation and recovery.

B. Classification of Yoga (5-8)

- Physical (Hatha Yoga): Primarily involves postures (asanas) and is often practiced for physical health.
- Mental and Spiritual (Bhakti Yoga): Involves devotion and meditation for emotional and spiritual growth.
- Intellectual (Jnana Yoga): Focuses on self-inquiry and knowledge, helping practitioners attain mental clarity.
- Service-Oriented (Karma Yoga): Centers around selfless actions to develop compassion and humility.

4. Benefits of Yoga in Disease Prevention and Management (8-10)

Yoga provides both preventive and therapeutic benefits for a wide range of chronic diseases:

- Cardiovascular Diseases: Regular yoga practice can lower blood pressure, reduce arterial stiffness, and improve lipid profiles.
- Diabetes: Certain postures enhance insulin sensitivity and reduce blood glucose levels.
- Mental Health Disorders: Yoga decreases stress hormone levels, alleviates symptoms of anxiety and depression, and improves mood.
- Respiratory Disorders: Pranayama techniques improve lung function, aiding individuals with asthma or chronic obstructive pulmonary disease (COPD).
- Musculoskeletal Disorders: Yoga enhances flexibility, strength, and reduces pain, beneficial for conditions like arthritis and chronic back pain.
- Immune System: Yoga's stress-reducing properties enhance immune function, making the body more resilient to infections.

5. Discussion

Yoga's holistic approach addresses both physical and psychological components of health, providing a balanced and sustainable method for disease management. Unlike conventional exercise, yoga incorporates a unique mind-body connection, which may play a key role in the therapeutic benefits seen across diverse conditions. Although further research is required to elucidate the precise mechanisms, current studies suggest that yoga influences the autonomic nervous system, reduces inflammation, and balances neuroendocrine functions. Considering these effects, yoga is becoming increasingly integrated into modern healthcare as an adjunctive therapy, offering a cost-effective, accessible solution for health maintenance and disease prevention (9-12).

6. Conclusion

Yoga, with its multifaceted approach, holds immense potential as a preventive and therapeutic tool in healthcare. By adopting various forms of yoga, individuals can enhance physical health, improve mental well-being, and mitigate the risk or impact of chronic diseases. As more research validates yoga's health benefits, its role in integrative medicine is likely to expand, supporting a holistic framework for patient-centered care.

7. References

1. Khalsa, S. B. S., et al. (2016). Yoga as a Therapeutic Intervention: A Bibliometric Analysis of Published Research Studies. Journal of Yoga & Physical Therapy.

2. Cramer, H., et al. (2017). Yoga for Health: The Evidence Is Growing. Evidence-Based Complementary and Alternative Medicine.
3. Ross, A., & Thomas, S. (2010). The Health Benefits of Yoga and Exercise: A Review of Comparison Studies. Journal of Alternative and Complementary Medicine.
4. Field, T. (2016). Yoga Research Review. Complementary Therapies in Clinical Practice.
5. Balasubramaniam, M., Telles, S., & Doraiswamy, P. M. (2013). Yoga on our Minds: A Systematic Review of Yoga for Neuropsychiatric Disorders. Frontiers in Psychiatry.
6. Javnbakht, M., Kenari, R. H., & Ghasemi, M. (2009). Effects of Yoga on Depression and Anxiety of Women. Complementary Therapies in Clinical Practice.
7. Innes, K. E., Selfe, T. K., & Taylor, A. G. (2008). Menopause, the Metabolic Syndrome, and Mind-Body Therapies. Maturitas.
8. Cramer, H., Lauche, R., Haller, H., & Dobos, G. (2014). A Systematic Review and Meta-Analysis of Yoga for Low Back Pain. Clinical Journal of Pain.
9. Streeter, C. C., et al. (2010). Effects of Yoga on the Autonomic Nervous System, Gamma-Aminobutyric-Acid, and Allostasis in Epilepsy, Depression, and Post-Traumatic Stress Disorder. Medical Hypotheses.
10. Raghavendra, R. M., et al. (2007). Effect of Yoga on Quality of Life in Cancer Patients. Indian Journal of Palliative Care.
11. Sherman, K. J., et al. (2011). Randomized Trial of Yoga and Stretching for Chronic Low Back Pain. Archives of Internal Medicine.
12. Woodyard, C. (2011). Exploring the Therapeutic Effects of Yoga and Its Ability to Increase Quality of Life. International Journal of Yoga.

Career Point International Journal of Research (CPIJR)
©2022 CPIJR | Volume 3 | Issue 3 | ISSN: 2583-1895

July-September-2024 | DOI: https://doi.org/10.5281/zenodo.14029553

Brachial Plexus Injury in Neonates: Causes, Recovery, and Treatment Approaches

Kalpesh Purohit[1], Sonal Joshi[2], Girish Kumar Vyas[3]

[1] Student, Jinzhou medical university, Jinzhou, Liaoning, China

[2] School of Pharmaceutical Studies, Dr. K. N. Modi University, Newai, Rajasthan

[3] Associate Professor, School of Pharmacy, Career Point University, Kota, Rajasthan

Author: Kalpeshpurohit8008@gmail.com, joshisonal1029@gmail.com, girishvyas10@gmail.com

Abstract

Brachial Plexus Injury (BPI) in neonates is a prevalent birth trauma characterized by damage to the brachial plexus nerves, typically resulting from excessive stretching during delivery. This review aims to elucidate the causes and risk factors associated with BPI, emphasize effective recovery exercises, and discuss treatment options that promote recovery in affected infants. Key causes include shoulder dystocia, assisted deliveries, breech births, and larger fetal size. Early intervention with a combination of physical therapy, such as passive range of motion exercises, stretching, tactile stimulation, and proprioceptive training is crucial for enhancing recovery potential. While mild to moderate cases often demonstrate significant improvement, severe injuries may require surgical intervention. This review highlights the importance of timely diagnosis and intervention, the variability of recovery timelines, and the need for ongoing research to optimize rehabilitation strategies for neonates with BPI. Ultimately, a comprehensive understanding of BPI's etiology and treatment approaches can significantly improve outcomes for affected infants and their families.

Keywords: Brachial Plexus Injury (BPI), neonatal birth trauma, BPI physical therapy, neonatal recovery timelines, therapeutic interventions for neonates.

1. Introduction

Brachial Plexus Injury (BPI) in neonates is a serious yet manageable condition resulting from trauma to the brachial plexus nerves, which run from the spinal cord through the neck to the shoulder, arm, and hand. Often occurring during childbirth, BPI leads to varying degrees of motor dysfunction in the upper limb. BPI in newborns, commonly associated with shoulder dystocia during labor, affects 1-2 per 1,000 live births globally. This injury can lead to long-term disability if not addressed with timely and appropriate interventions. Hence, understanding BPI's etiology, recovery processes, and therapeutic options is essential for healthcare professionals and parents (1-3).

Career Point International Journal of Research (CPIJR)
©2022 CPIJR | Volume 3 | Issue 3 | ISSN: 2583-1895
July-September-2024 | DOI: https://doi.org/10.5281/zenodo.14029553

2. Objective of this Review

- Outline the causes and risk factors associated with Brachial Plexus Injury in neonates.
- Describe effective treatment and recovery exercises available to support neonatal BPI recovery.
- Discuss prognosis and the expected recovery timeline for BPI, focusing on evidence-based exercises.
- Highlight gaps in research and explore emerging rehabilitation strategies to improve neonatal outcomes (4,5).

3. Causes of Brachial Plexus Injury

Brachial Plexus Injury in neonates typically occurs due to excessive stretching, compression, or tearing of the brachial plexus nerves during delivery (4-7). Common causes include:

A. **Shoulder Dystocia:** When the infant's shoulder becomes lodged against the maternal pelvis during childbirth, resulting in forceful stretching of the brachial plexus nerves.

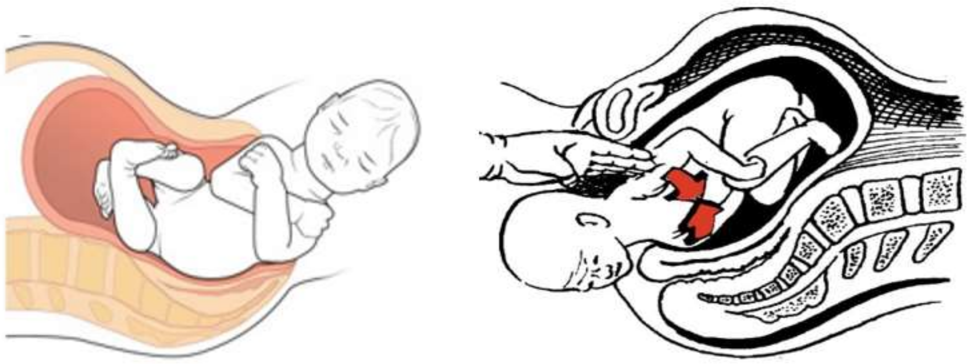

Figure 1: Shoulder Dystocia at child birth by hands or rotation

B. **Assisted Deliveries:** The use of forceps or vacuum extraction during childbirth may increase the risk of nerve injury.

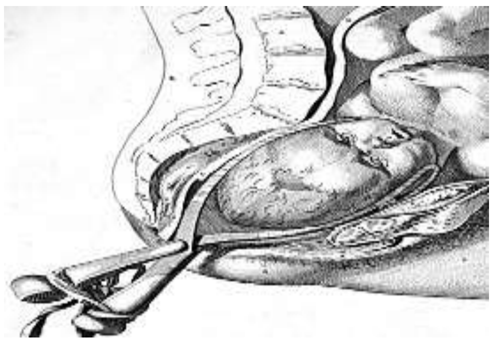

Figure 2: Forceps or vacuum extraction at child birth

C. **Breech Births:** In breech presentations, abnormal fetal positioning can lead to undue pressure on the arms and shoulders.

Figure 3: Abnormal Fetal Positioning or Breech Births

D. **Larger Fetal Size:** Larger infants (macrosomia) may be at greater risk of BPI due to the increased difficulty in passing through the birth canal.

4. Recovery Exercises and Treatment Options

Effective management of Brachial Plexus Injury combines non-invasive therapeutic exercises with, in some cases, surgical interventions. Early intervention is critical to maximize recovery potential and prevent complications (3, 5, 7-9).

4.1 Recovery Exercises

Physical therapy exercises aim to promote muscle strength, flexibility, and nerve recovery. Exercises should be introduced in the early weeks of life under a trained therapist's supervision.

- **Passive Range of Motion (PROM) Exercises**: Gentle movement of the infant's arm through its natural range of motion to prevent stiffness.

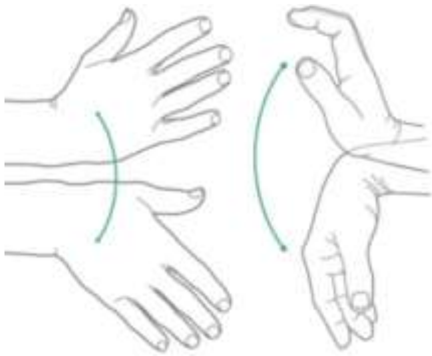

Figure 4: Movement of wrist to prevent stiffness

- **Stretching and Flexibility Exercises:** Specific stretching exercises for the shoulder and elbow joints help maintain flexibility, improve circulation, and facilitate nerve recovery.

Figure 5: Stretching and Flexibility Exercises

- **Tactile Stimulation:** Lightly stimulating the skin around the affected area enhances nerve sensitivity and promotes sensory feedback.

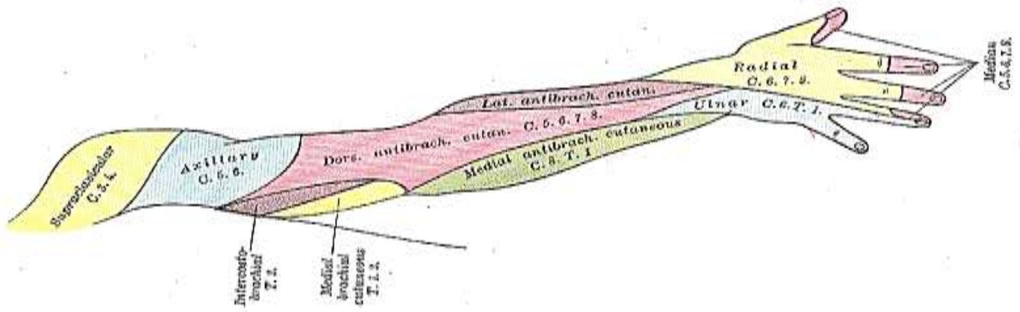

Figure 6: Tactile Stimulation for nerve sensitivity

- **Proprioceptive Training**: Exercises involving gentle weight-bearing through the arm, aiding proprioception and improving motor control in recovering muscles.

4.2 Additional Treatments

- Occupational Therapy: Tailored to support fine motor skills and hand function as the infant grows.
- Electrical Stimulation Therapy: For severe cases, low-intensity electrical stimulation may be used to stimulate muscle contractions and promote nerve function.
- Surgical Intervention: In cases of significant nerve damage, surgical options like nerve grafting or transfers may be considered, typically within the first 6-12 months if there is little to no recovery (8,9).

Career Point International Journal of Research (CPIJR)
©2022 CPIJR | Volume 3 | Issue 3 | ISSN: 2583-1895
July-September-2024 | DOI: https://doi.org/10.5281/zenodo.14029553

5. Discussion

Brachial Plexus Injury in neonates presents both short- and long-term challenges for families and healthcare professionals. Studies indicate that early and consistent physical therapy can yield positive outcomes, with 70-90% of mild to moderate cases showing considerable improvement by six months. While passive exercises are commonly recommended, recent evidence suggests that active movement and weight-bearing exercises significantly aid nerve regeneration. Additionally, the combination of tactile stimulation with physical therapy exercises enhances recovery rates, especially when initiated within the first few weeks of life.

The prognosis of BPI depends on the extent of the initial nerve damage. Injuries involving only minor stretching of the brachial plexus nerves generally show spontaneous recovery. However, nerve rupture or avulsion may necessitate surgical intervention. Future research is needed to explore genetic and cellular factors influencing nerve regeneration, as well as innovations in therapeutic exercises for improving muscle strength and function in BPI-affected limbs (7-10).

6. Conclusion

Brachial Plexus Injury is a critical condition that, if identified early, can often be effectively managed through a combination of physical therapy exercises and, in severe cases, surgical intervention. Understanding the etiology, optimal treatment methods, and realistic recovery timelines allows caregivers and healthcare providers to support infants effectively. Early intervention is paramount for favorable outcomes, emphasizing the importance of prompt diagnosis and therapy initiation. As more research on nerve regeneration emerges, the potential for improved rehabilitation methods will continue to evolve, offering hope for neonates affected by this condition.

7. References

1. Pondaag W, Malessy MJA. The evidence for nerve repair in obstetric brachial plexus palsy revisited. Biomed Res Int. 2014;2014:434619.
2. Hale HB, Bae DS, Waters PM. Current concepts in the management of brachial plexus birth palsy. J Hand Surg Am. 2010;35(2):322-331.
3. Mohammad M, Zuo KJ, Mioton LM, et al. The natural history of neonatal brachial plexus palsy. J Pediatr Orthop. 2014;34(4):388-394.

4. Ho ES, Curtis CG, Clarke HM. Pediatric evaluation of disability inventory before and after primary surgery for obstetric brachial plexus palsy. J Hand Surg Am. 2006;31(8):1337-1342.
5. Everson RE, Wilkes D, Awad A. Early and late microsurgical reconstruction of the brachial plexus following birth trauma. Plast Reconstr Surg. 2015;136(6):1381-1388.
6. Singh J, Shah H, Doddabasappa SN, Joseph B. Obstetric brachial plexus palsy: Management and outcome. Indian J Orthop. 2014;48(5):427-431.
7. Berger A, Fries PD, Sarwark JF. Brachial plexus palsy: Evaluation and management. J Am Acad Orthop Surg. 2021;29(16):e804-e815.
8. Garg R, Merrell GA, Hillstrom HJ, Wolfe SW. Brachial plexus birth palsy: Management and outcomes. Clin Orthop Relat Res. 2011;469(9):2478-2484.
9. Verhage SM, Postema SG, van der Sluijs JA, et al. Factors associated with recovery of shoulder function in children with obstetric brachial plexus injury. J Pediatr Orthop. 2017;37(7):e440-e445.
10. Al-Qattan MM. Obstetric brachial plexus palsy associated with breech delivery. Ann Plast Surg. 2003;51(3):257-264.

Career Point International Journal of Research (CPIJR)
©2022 CPIJR | Volume 3 | Issue 3 | ISSN: 2583-1895

July-September-2024 | DOI: https://doi.org/10.5281/zenodo.14029558

Current Perspectives on the Etiology and Management of Nocturnal Enuresis in Children: A Review

Lalit Gargiya[1], Keshav Gautam[2], Girish Kumar Vyas[3]

[1] Senior QA Manager, GeBBS Healthcare Solutions, Mumbai

[2] Assistant Professor, Alwar College of Pharmacy, Alwar, Rajasthan

[3] Associate Professor, School of Pharmacy, Career Point University, Kota, Rajasthan

Correspondence Author: gargiyalalit@gmail.com, Keshav.gautam04@gmail.com, girishvyas10@gmail.com

Abstract

Nocturnal enuresis (NE), or bed-wetting, is a common paediatric condition characterized by involuntary urination during sleep in children aged five and older, impacting approximately 15-20% of children at this age and declining with maturation. NE's multifactorial etiology encompasses genetic, physiological, and psychological factors, which complicates its management. This review aims to consolidate current knowledge on NE, examining its types, risk factors, pathophysiology, impact on quality of life, diagnostic methods, and therapeutic options. Behavioral interventions, bed-wetting alarms, and pharmacotherapy, including desmopressin, are standard treatments, while combination therapies and personalized approaches show promising efficacy. Emerging treatments focusing on genetic and physiological insights highlight the potential for targeted management. Further research into the complex interplay of genetic and environmental factors, as well as the long-term effects of treatment modalities, is essential for reducing the social and psychological impact of NE and improving outcomes for affected children and their families.

Keywords: Nocturnal enuresis, paediatric urology, bed-wetting treatment, pathophysiology, quality of life.

1. Introduction

Nocturnal enuresis (NE), commonly referred to as bed-wetting, is an involuntary urination during sleep in children aged five and older. NE affects approximately 15-20% of children at age five and gradually declines with age, persisting in about 1-2% of adolescents and young adults. It is classified as a paediatric condition, although its impact extends to psychological and social domains, affecting self-esteem and quality of life.

Career Point International Journal of Research (CPIJR)
©2022 CPIJR | Volume 3 | Issue 3 | ISSN: 2583-1895
July-September-2024 | DOI: https://doi.org/10.5281/zenodo.14029558

Despite its prevalence, the exact mechanisms remain unclear, and treatment approaches vary widely, ranging from behavioral interventions to pharmacotherapy. Understanding the multifactorial etiology, pathophysiology, and effective management strategies is crucial for clinicians and researchers working with affected children and their families (1-3, 5).

2. Objective of This Review

- To Summarize the current understanding of nocturnal enuresis, including its types, risk factors, and pathophysiology.
- Outline available diagnostic criteria and methods.
- Examine the impact of NE on quality of life.
- Discuss current treatment options and emerging therapies.
- Identify areas requiring further research and potential advancements in personalized treatment approaches (3-5).

3. Material and Methods

This review was conducted by analyzing published literature on nocturnal enuresis from reputable databases such as PubMed, Scopus, and Google Scholar. Keywords included “nocturnal enuresis,” “bed-wetting,” “paediatricurology,” “pathophysiology of nocturnal enuresis,” and “treatment of bed-wetting.” Articles from 2000 to 2023 were prioritized to provide a current understanding of NE. Both original research articles and systematic reviews were included. Studies focusing on primary NE in children aged 5 and older were emphasized, with limited inclusion of studies on secondary NE or NE in adult populations (2-5).

4. Results

Types of Nocturnal Enuresis

NE can be classified into:

- Primary Nocturnal Enuresis (PNE): When a child has never achieved nighttime dryness.
- Secondary Nocturnal Enuresis (SNE): When bed-wetting resumes after a period of dryness of six months or longer.

Additionally, NE is categorized as:

- Monosymptomatic NE (MNE): Enuresis without other urinary symptoms.

Career Point International Journal of Research (CPIJR)
©2022 CPIJR | Volume 3 | Issue 3 | ISSN: 2583-1895
July-September-2024 | DOI: https://doi.org/10.5281/zenodo.14029558

- Non-monosymptomatic NE (NMNE): Enuresis accompanied by other urinary symptoms, such as urgency or frequency during the day (2,3).

Etiology and Risk Factors

NE has a multifactorial etiology with contributions from:

- Genetic Predisposition: Family history strongly influences the likelihood of NE, with children having a 75% chance of NE if both parents were affected.
- Developmental Factors: Delayed maturation of bladder control mechanisms.
- Psychological Factors: NE may be linked to stress or trauma, particularly in cases of secondary NE.
- Bladder Dysfunction and ADH Levels: Reduced nocturnal bladder capacity and inadequate secretion of antidiuretic hormone (ADH) during sleep.
- Sleep Disorders: Some studies suggest that children with NE have altered sleep patterns or deeper sleep stages, reducing their ability to respond to bladder fullness (4,5).

Impact on Quality of Life

Children with NE may experience psychological distress, low self-esteem, and social embarrassment, particularly as they approach adolescence. The condition can impact family dynamics and lead to academic challenges due to sleep disturbances and related stress. Treatment Approaches are given below:

1. Behavioral Therapy: Including fluid restriction, bladder training, and motivational therapies.
2. Bed-Wetting Alarms: Effective in conditioning the child to wake up at the sensation of a full bladder.
3. Pharmacotherapy: Desmopressin (an ADH analog) and anticholinergic drugs are commonly used, with desmopressin being the first-line pharmacological treatment for monosymptomatic NE.
4. Combination Therapy: Behavioral therapy combined with pharmacological treatments has shown higher success rates.
5. Emerging Treatments: Current research is exploring the role of genetics in treatment customization and new pharmacological agents targeting underlying physiological mechanisms (3-6).

5. Discussion

Nocturnal enuresis is a complex condition with a variety of contributing factors. The categorization of NE into primary/secondary and monosymptomatic/non-monosymptomatic forms has allowed more targeted research and treatment approaches. Current evidence supports the role of genetic predisposition, as children with a family history of NE have a higher risk. However, the interplay between genetic, developmental, and environmental factors remains incompletely understood.

The pathophysiology of NE highlights a deficiency in ADH secretion at night, resulting in high nocturnal urine production. Combined with a smaller functional bladder capacity and potential sleep arousal issues, these factors contribute to the inability to maintain nighttime dryness. Diagnostic evaluation should include a thorough history and physical examination to identify any underlying urinary tract disorders or other contributing medical conditions (4,5).

Treatment of NE has evolved significantly, moving from punitive measures to evidence-based behavioral therapies and medication. Behavioral interventions, especially when paired with bed-wetting alarms, have shown long-term success. Pharmacological treatments like desmopressin offer relief for children with monosymptomatic NE but may not be suitable for all cases, particularly if underlying bladder dysfunction is present. While combination therapies and personalized treatment approaches are promising, more research is required to better understand the role of emerging therapies and to explore the long-term effects of pharmacological interventions on children (5,6).

6. Conclusion

Nocturnal enuresis is a prevalent condition that impacts not only physical health but also psychological and social well-being. Understanding its multifactorial etiology, including genetic and physiological contributors, is essential for developing effective treatment strategies. While behavioral interventions and pharmacotherapy remain the primary management approaches, recent advances in understanding NE's pathophysiology and the role of sleep and bladder function may lead to more targeted therapies. Future research should focus on personalized treatment approaches, exploring genetic markers, and developing novel therapeutic agents to reduce the burden of nocturnal enuresis on affected children and their families.

7. References

1. Caldwell PH, Deshpande AV, Von Gontard A. Management of nocturnal enuresis. BMJ. 2013;347:f6259.
2. Von Gontard A, Freitag CM. The genetics of nocturnal enuresis: A review. J Urol. 2012;188(4):1416-1422.
3. Yeung CK, Sit FKY, Fok TF, Leung V, Lau J, Chang SM. Differences in the sleep patterns of enuretic and non-enuretic children. Br J Urol Int. 2004;93(3):341-345.
4. Nevéus T, von Gontard A, Hoebeke P, Hjalmas K, Bauer S, Bower W, et al. The standardization of terminology of lower urinary tract function in children and adolescents: Report from the International Children's Continence Society. J Urol. 2010;176(1):314-324.
5. Butler RJ, Holland P. The child's opinion on nocturnal enuresis and its treatment. Scand J Urol Nephrol. 2000;34(1):1-7.
6. Hägglöf B, Andrén O, Bergström E, Marklund L, Wendelius M. Quality of life in children with nocturnal enuresis. Acta Paediatr. 1998;87(6):567-573.

Career Point International Journal of Research (CPIJR)
©2022 CPIJR | Volume 3 | Issue 3 | ISSN: 2583-1895

July-September-2024 | DOI: https://doi.org/10.5281/zenodo.14029564

Impact of Weather Variability on Solar Energy Production Forecasting

Jitesh Vyas[1], Durgesh Nandan Verma[2]

[1]Former Student, Govt. Polytechnic College Kota, Rajasthan

Assistant Professor, Department of Civil Engineering, Dr. K. N. Modi University, Newai, Rajasthan

Correspondence Author: jiteshvyas23@gmail.com

Abstract

Solar energy is a pivotal renewable resource in the transition to sustainable energy systems, but its integration is challenged by significant weather variability that affects production forecasting. This review explores the impact of weather variability on solar energy generation, highlighting critical weather parameters—solar irradiance, cloud cover, temperature, and humidity—that directly influence photovoltaic performance. The article discusses various forecasting methods, including statistical techniques, physical models, machine learning algorithms, and hybrid approaches, each with its advantages and limitations. Accurate solar forecasting is essential for enhancing grid stability, economic efficiency, and energy management, thereby facilitating the effective integration of solar power into the energy grid. As the adoption of solar energy expands, advancing forecasting methodologies will be crucial for optimizing energy production and supporting global climate change mitigation efforts. The review underscores the importance of ongoing research into weather parameters and innovative forecasting technologies to improve solar energy production forecasting and ensure a reliable, sustainable energy future.

Keywords: Solar energy, weather variability, forecasting methods, photovoltaic performance, renewable energy integration.

1. Introduction

Solar energy is a rapidly growing component of the renewable energy landscape, driven by its potential to reduce greenhouse gas emissions and dependence on fossil fuels. However, the variability in weather conditions poses significant challenges for accurately forecasting solar energy production. Weather parameters such as solar irradiance, cloud cover, temperature, and humidity directly influence solar panel performance. Understanding these factors is essential for optimizing solar energy integration into the energy grid, ensuring reliability, and maximizing the efficiency of solar energy systems. This review article aims to outline the impact of weather variability on solar energy production forecasting, highlight the key weather parameters affecting solar energy generation, and discuss effective forecasting methods that can mitigate the effects of weather variability (1,2).

2. Objectives

- To analyze the impact of weather variability on solar energy production.
- To identify the key weather parameters that affect solar energy forecasting accuracy.
- To discuss various forecasting methods and technologies used to predict solar energy production.
- To highlight the importance of accurate forecasting in the context of renewable energy integration and grid stability.

3. Weather Variability and Its Impact on Solar Energy Production

Weather variability refers to the natural fluctuations in weather conditions that can affect solar energy generation. These fluctuations can lead to significant discrepancies between forecasted and actual energy production, impacting grid management and the overall effectiveness of solar power systems (3,4).

A. Solar Irradiance: Solar irradiance is the primary driver of solar energy production. Variations in solar irradiance occur due to factors such as cloud cover, atmospheric conditions, and seasonal changes. Clouds can block sunlight, leading to substantial reductions in solar power generation. For instance, during overcast conditions, solar panels may generate only 10-20% of their rated capacity. Accurate forecasting of solar irradiance is crucial for predicting energy production and ensuring effective energy management.

B. Cloud Cover and Weather Patterns: Cloud cover significantly influences solar energy production. The movement of clouds can cause rapid changes in irradiance levels, leading to difficulties in real-time forecasting. Moreover, different types of clouds affect solar energy generation differently. For instance, thick cumulonimbus clouds can severely diminish solar output, while thin cirrus clouds may have a negligible effect. Understanding the dynamics of cloud cover and its correlation with solar energy production is vital for improving forecasting accuracy.

C. Temperature and Humidity: Temperature and humidity also play essential roles in solar panel efficiency. High temperatures can reduce the efficiency of solar photovoltaic (PV) cells, while increased humidity can impact the reflectivity of solar panels. Additionally, temperature variations can affect the electrical performance of solar systems, leading to deviations from expected energy output. Forecasting models must incorporate these parameters to enhance accuracy (3,4).

CAREER POINT INTERNATIONAL JOURNAL OF RESEARCH

Career Point International Journal of Research (CPIJR)
©2022 CPIJR | Volume 3 | Issue 3 | ISSN: 2583-1895

July-September-2024 | DOI: https://doi.org/10.5281/zenodo.14029564

4. Forecasting Methods and Technologies

Several forecasting methods are employed to predict solar energy production, each with its advantages and limitations. The choice of method often depends on the specific requirements of the solar energy system and the local climate conditions (3-6).

A. Statistical Methods: Statistical methods utilize historical data to predict future solar energy production. Techniques such as time series analysis, regression models, and correlation methods can be employed to analyze patterns in historical irradiance and production data. While these methods can provide reasonable forecasts, they may not adequately account for sudden weather changes (3,4).
B. Physical Models: Physical models simulate atmospheric processes to forecast solar energy production. These models utilize meteorological data, such as temperature, humidity, wind speed, and cloud cover, to predict solar irradiance. While physical models can offer more accurate forecasts under varying weather conditions, they often require significant computational resources and expertise in meteorology (5).
C. Machine Learning Techniques: The application of machine learning algorithms has gained prominence in solar energy forecasting due to their ability to analyze large datasets and identify complex patterns. Techniques such as artificial neural networks (ANNs), support vector machines (SVMs), and decision trees can be employed to improve forecasting accuracy. Machine learning models can adapt to changing weather patterns and learn from historical data, making them highly effective for solar energy production forecasting.
D. Hybrid Approaches: Hybrid approaches combine statistical methods, physical models, and machine learning techniques to enhance forecasting accuracy. By integrating multiple methods, hybrid models can leverage the strengths of each technique while minimizing their limitations. For example, a hybrid model may use statistical analysis for short-term forecasts and machine learning for long-term predictions, resulting in a more comprehensive forecasting solution (4-6).

5. Importance of Accurate Forecasting for Renewable Energy Integration

Accurate solar energy production forecasting is critical for the successful integration of solar power into the energy grid. As solar energy generation is inherently variable, forecasting

Career Point International Journal of Research (CPIJR)
©2022 CPIJR | Volume 3 | Issue 3 | ISSN: 2583-1895
July-September-2024 | DOI: https://doi.org/10.5281/zenodo.14029564

allows grid operators to balance supply and demand effectively (5,6). Improved forecasting can lead to several benefits:

A. Grid Stability: Accurate forecasts enable grid operators to manage fluctuations in solar energy production, reducing the risk of blackouts and enhancing grid stability. By anticipating changes in energy generation, grid operators can adjust other energy sources to compensate for variations in solar output (7).
B. Economic Efficiency: Reliable forecasting can enhance economic efficiency by reducing the need for backup generation capacity and minimizing energy waste. By optimizing energy dispatch based on accurate forecasts, utilities can lower operational costs and improve overall system efficiency (7-9).
C. Enhanced Energy Management: Accurate solar forecasting enables energy producers to make informed decisions regarding energy storage and distribution. This proactive approach allows for better utilization of renewable resources and reduces reliance on fossil fuels (8-10).

6. Discussion

The impact of weather variability on solar energy production forecasting is significant, underscoring the importance of accurate predictive models. While traditional statistical methods and physical models have their strengths, the emergence of machine learning techniques presents exciting opportunities for improving forecasting accuracy. As the adoption of solar energy continues to grow, enhancing forecasting methods will be crucial for effective energy management and grid integration (7,9).

The integration of machine learning and hybrid approaches can potentially revolutionize solar energy forecasting, leading to more reliable predictions that can accommodate the inherent variability of weather conditions. Further research into the interplay of various weather parameters and the development of innovative forecasting technologies will be essential for optimizing solar energy production (7,10).

7. Conclusion

Weather variability significantly impacts solar energy production forecasting, necessitating the development of accurate and reliable forecasting methods. Understanding the key weather parameters that influence solar energy generation is crucial for improving forecasting accuracy. As technology continues to evolve, integrating advanced forecasting techniques such as machine learning and hybrid models will enhance the ability to predict solar energy

Career Point International Journal of Research (CPIJR)
©2022 CPIJR | Volume 3 | Issue 3 | ISSN: 2583-1895
July-September-2024 | DOI: https://doi.org/10.5281/zenodo.14029564

production, facilitating the integration of solar power into the energy grid. This advancement will ultimately support the transition toward a more sustainable energy future, contributing to the global effort to mitigate climate change.

8. References

1. Gómez-Navarro T, López-Cruz I, Sánchez-Santana J, Martínez-Sánchez C, Marín F. Review of solar forecasting methods. Renewable Sustainable Energy Rev. 2018;93:470-82.
2. Kjaer KJ, Hojstrup J, Pilegaard K, et al. Assessing the impact of cloud cover on solar energy production forecasts. Solar Energy. 2020;209:122-32.
3. Trujillo AJ, Martínez-Rodríguez I, Almendros-Ibáñez J, et al. Machine learning approaches for solar energy forecasting: A review. Renewable Energy. 2019;142:32-43.
4. Bacher P, Madsen H. Forecasting of solar radiation: A review of recent advances. Renewable Sustainable Energy Rev. 2009;13(8):2131-44.
5. Ahmed K, Chowdhury M, Hossain N, et al. The influence of weather conditions on photovoltaic performance: A comprehensive review. Energy Reports. 2021;7:176-85.
6. Liu H, Zhang X, Zheng Y, et al. A hybrid forecasting model for solar energy production using deep learning. Appl Energy. 2018;228:1215-26.
7. Khatib TM, Omer AM, Ali MS, et al. Evaluation of weather forecasting models for solar energy production prediction. Energy. 2016;95:229-39.
8. Luthra S, Mangla SK. Role of predictive analytics in enhancing solar energy generation. Int J Energy Sector Manag. 2020;14(3):543-59.
9. Uddin K, Huq S, Rahman M, et al. Cloud cover and its impact on solar energy production: A case study in Bangladesh. Renewable Energy. 2019;136:143-56.
10. Soares J, de Almeida A, Afonso A, et al. The potential of using satellite data for solar energy forecasting. Remote Sens. 2020;12(3):476.

CAREER POINT INTERNATIONAL JOURNAL OF RESEARCH

Career Point International Journal of Research (CPIJR)
©2022 CPIJR | Volume 3 | Issue 3 | ISSN: 2583-1895
July-September-2024 | DOI: https://doi.org/10.5281/zenodo.14029572

Paracetamol (Acetaminophen): An Intimate Drug with Unexplained Adverse Effects on Body

Shiv Pratap Singh[1], Girish Kumar Vyas[2]

[1] Student, Bachelor of Pharmacy, School of Pharmacy, Career Point University, Kota, Rajasthan

[2] Associate Professor, Department of Chemistry, School of Pharmacy, Career Point University, Kota, Rajasthan

Correspondence author: singhshiv9660@gmail.com

Abstract

Paracetamol (acetaminophen) is the most used drug in the world, with a long record of use in acute and chronic pain. In recent years, the benefits of paracetamol use in chronic conditions has been questioned, notably in the areas of osteoarthritis and lower back pain. Over the same period, concerns over the long-term adverse effects of paracetamol use have increased, initially in the field of hypertension, but more recently in other areas as well. The evidence base for the adverse effects of chronic paracetamol use consists of many cohort and observational studies, with few randomized controlled trials, many of which contradict each other, so these studies must be interpreted with caution. Nevertheless, there are some areas where the evidence for harm is more robust, and if a clinician is starting paracetamol with the expectation of chronic use it might be advisable to discuss these side effects with patients beforehand. An increased risk of gastrointestinal bleeding and a small (~4 mmHg) increase in systolic blood pressure are adverse effects for which the evidence is particularly strong, and which show a degree of dose dependence. As our estimation of the benefits decreases, an accurate assessment of the harms is ever more important. The present review summarizes the current evidence on the harms associated with chronic paracetamol use, focusing on cardiovascular disease, asthma and renal injury, and the effects of *in utero* exposure.

Keywords: Paracetamol, Cyclooxygenase, Thermoregulation, Acetaminophen, Adverse effects.

Introduction

Paracetamol (acetaminophen, N-acetyl-*p*-aminophenol) is one of the most widely used over-the-counter analgesic antipyretic drugs. It was first synthesized by Joseph von Mering in (1893) by reacting *p*-nitrophenol with tin and glacial acetic acid. In the 1880s paracetamol and phenacetin figure(1) were found to possess antipyretic and later analgesic activity. Initially, phenacetin gained more popularity than paracetamol and was marketed in 1887; however, because of the serious side effects associated with phenacetin such as hemolytic anemia and methemoglobin formation, its clinical use declined, and attention focused on paracetamol, which was marketed in 1893 .

1. Additionally, more studies on phenacetin in the 1940s showed that paracetamol is one of its major metabolites and thus its pharmacological effects are attributed to paracetamol.
2. As a result, paracetamol became freely available from the 1950s and has become the most widely used over-the-counter non-narcotic analgesic agent for the treatment of mild to moderate pain and fever.

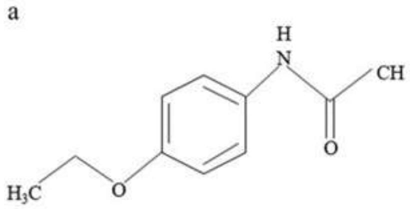

Figure 1: a. Paracetamol

Paracetamol now dominates the market of over-the-counter non-narcotic analgesic drugs following the demonstration of its safety profile at therapeutic doses and particularly after aspirin usage began to decline since the 1960s due to its gastrointestinal toxicity and association with Reye's Syndrome in children .

3. Today paracetamol is the standard and first-line treatment for fever and acute pain and is believed to remain so for many years to come .
4. This is mainly due to its outstanding safety record at therapeutic doses when compared to the non-steroidal anti-inflammatory drugs (NSAIDs). Sales of paracetamol, most widely consumed over-the-counter analgesic drug, have been on the increase for the past few years – a trend that it is predicted to continue.

The uses of paracetamol

Paracetamol was introduced into the pharmacological market in 1955 by McNeil aboratories as a prescribed analgesic and anupyretic drug lor children under its trade name Tvlenol Children's Bluxu (the name tvleno derives from its chemical name N-acetv-D-aminodheno. One vear later. 300-mg tablets or paracelamol were available over the counter in Great Britain under the trade name of Panadol, which were produced by

Frederick Stearns & Co, the branch of Sterling Drug Inc. In Poland. paracetamo became available in 96 and since then it has belonged to the one of the most frequent-v sold analgesic medications. There are about a 100 preparations in the trade offer, which contain pard cetamol alone or in combination with other active.

The paracetamol place on the WHO analgesic ladder, which precisely defines the rules for applica-lion of analgesic drugs. is impressive. This drug has been placed on all three steps of pain treatment intensity. In different pains or moderate intensity. paracetamol as a weak analgesic together with non-steroidal analgesic drugs or co-analgesics e.g., caffeine) is a basic non-opioid analgesic (the first step of the analgesic ladder). When pain maintains or increases. paracetamol is used as an additional analgesic with weak (e.g., caffeine, tramadol) or strong (e.g. morphine. pentenyl) opioids from the second and third step of the analgesic ladder, respectively.

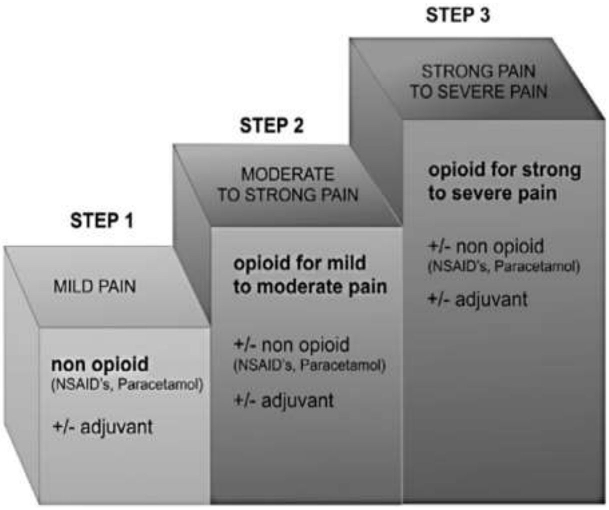

Figure 2: Paracetamol with WHO ladder

Paracetamol, if efticient, is a recommended oral analgesic of a first choice to be used for a long time, e.g., in symptomatic treatment of slight and moderate pain occurring in osteoarthritis as well as in muscle or tendon pains. Moreover, it is a drug of choice in patients in whom application of non-steroidal anti-inflammatory drugs (NSAIDs) are contraindicated, e.g., in the case of gastric ulcers, hypersensitivity to aspirin, impairments in blood coagulation, in pregnant women, nursing mothers and children with fever accompanying a disease (5).

The use of paracetamol in children requires special care and maintain in an adequate dosage (based on age), which significantly differs from standard adult.

The recommended dosage for children considers the metabolism of paracetamol, which determines the toxicity of the drug, especially hepatotoxicity (see below). In children, paracetamol metabolism changes with age: in younger children the sulfation pathway is dominated route of paracetamol elimination (which is mature at birth); the glucuronidation pathway takes about two years to mature. The oxidation of paracetamol, which takes place mainly with the participation of the enzyme CYP2E1 in neonates
is negligible, because the activity of CYP2E1 increases with age, reaching the adult value at age 1-10 years. For comparison, in adults, paracetamol is metabolized mainly in the liver via glucuronidation (50-60%), sulfation (25-30%) and oxidation (< 10%) (see below in the section on adverse effects). Therefore, according to Ji et al. (6), the proposed dosage of paracetamol in children up to 12 years is as follows:

- under 2 years - no recommended dose: treatment under the supervision of a physician;
- 2-3 years - 160 mg (daily dose divided into two dose units, i.e., 2 × 80 mg); total dose corresponds to 1/2 of a single dose for an adult, i.e., 325 mg;
- 4-6 years - 240 mg (daily dose divided into three dose units, i.e., 3 x 80 mg); total dose corresponds to 3/4 of a single dose for an adult;
- 6-9 years - 320 mg (daily dose divided into four dose units, i.e., 4 × 80 mg); total dose is the same as a single dose for an adult;
- 9-11 years - 320-400 mg (daily dose divided into four-five dose units, i.e., 4-5 × 80 mg; total dose corresponds to 1-1 1/4 of a single dose for an
- 11-12 years - 320-480 mg (daily dose divided in the four-six dose units, ie 4-6 × 80 mg; total dose corresponds to 1 - 1 1/2 of a single dose for an adult.

According to the 20th edition of Drugs of Contemporary Therapy (Polish), the acetaminophen dosage schedules in paediatric patients should be as follows: 10-15 mg/kg oral dose and 15-20 mg/kg rectal dose every 4-6 h, maximum of 5 doses/day; in newborns orally or rectally 10 mg/kg of body weight every 4 h or 15 mg/kg every 6 h (maximum daily dose in newborns is 60 mg/kg).(7)

Mechanisms of action

It is surprising that after more than 100 years, the exact mechanism of action of paracetamol remains to be determined. There is evidence for several central mechanisms, including effects on prostaglandin production, and on serotonergic, opioid, nitric oxide

(NO), and cannabinoid pathways, and it is likely that a combination of interrelated pathways are in fact involved. A few of these are outlined below (8,9)

Prostaglandin inhibition

Paracetamol is termed a simple analgesic and an antipyretic. Despite enduring assertions that it acts by inhibition of cyclooxygenase (COX)-mediated production of prostaglandins, unlike non-steroidal anti-inflammatory drugs (NSAIDs), paracetamol has been demonstrated not to reduce tissue inflammation. Two explanations have been put forward for this.

The enzyme responsible for the metabolism of arachidonic acid to the prostanoids (including prostaglandins and thromboxanes), commonly referred to as cyclooxygenase, is also more appropriately called prostaglandin H2 synthetase (PGHS), and possesses two active sites: the COX and the peroxidase (POX) sites. The conversion from arachidonic acid to the prostanoids is in fact a two-stage process, requiring activity at the COX site to first produce the unstable intermediate hydroperoxide, prostaglandin G2 (PGG2), which is then converted to prostaglandin H2 (PGH2) via POX. The enzymatic activity of COX relies on its being in the oxidized form and it is suggested that paracetamol interferes indirectly with this by acting as a reducing co-substrate at the POX site. In intact cells, when levels of arachidonic acid are low, paracetamol is a potent inhibitor of PG synthesis, by blocking the physiological regeneration of POX. However, in broken cells, where the concentration of hydroperoxides is high, prostaglandin synthesis is only weakly inhibited. This peroxidedependent COX inhibition explains the differential activity of paracetamol in the brain where peroxide concentrations are low, vs peripheral sites of inflammation with high peroxide levels as showed in figure 3.

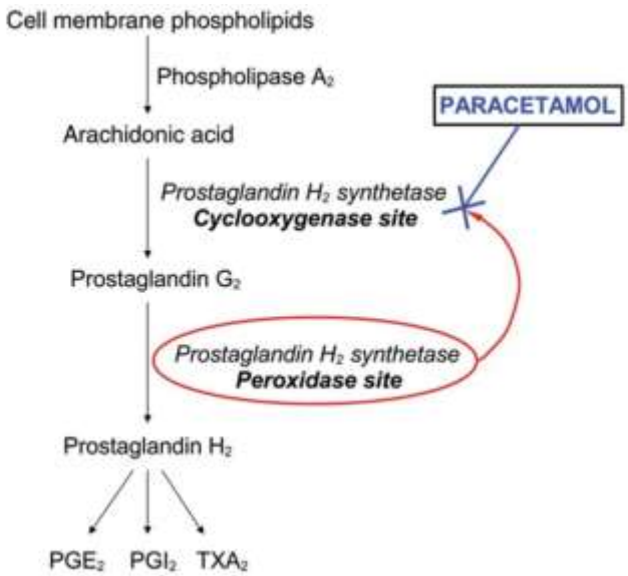

Figure 3: Role of paracetamol in inhibition of prostaglandin production.

An alternative suggestion was that, unlike NSAIDS, which act on COX-1 and -2, paracetamol may act on a discrete COX-1 splice variant (initially thought to be a distinct isoenzyme, COX-3). This COX-1 variant was thought to be active in the central nervous system, rather than at the site of injured or inflamed tissue, such that inhibition by paracetamol here would explain its lack of anti-inflammatory and anti-platelet activity, whilst still affording it highly effective analgesic and antipyretic properties. However, the original work for this was performed on canine tissue, in which the COX-1 splice variant retains a COX-like action; in humans, however, the expressed protein has no role in the physiology of prostaglandins. (8,9,10)

Serotoninergic pathway activation

Serotonergic pathways are part of the descending pain system, originating in the brainstem nuclei, hypothalamus, and cortex, and interact with pain afferents in the dorsal horn. Serotonin receptors are present throughout the central nervous system, involved in several functions, including consciousness, mood, memory, and nausea and vomiting, the latter of which are mediated via the 5-HT3-receptor subtype. It has become widely accepted that the activation of descending serotonergic pathways plays a key role in the action of paracetamol, and it has been demonstrated that the anti-nociceptive effects of paracetamol can be partially inhibited by co-administration of 5-HT3-receptor antagonists, interestingly using anti-emetic drugs which are indeed frequently given together with paracetamol in the perioperative period. (10)

Career Point International Journal of Research (CPIJR)
©2022 CPIJR | Volume 3 | Issue 3 | ISSN: 2583-1895
July-September-2024 | DOI: https://doi.org/10.5281/zenodo.14029572

Endocannabinoid enhancement

In the presence of fatty acid amide hydrolase (FAAH), an enzyme found predominantly in the central nervous system, paracetamol (via an intermediary, p-aminophenol, formed in the liver) is conjugated with arachidonic acid to form the active metabolite, Narachidonoylphenolamine (AM404). Analogous to the action of serotonin or norepinephrine reuptake inhibitors, AM404 inhibits the reuptake of the endocannabinoid, anandamide, from synaptic clefts, increasing cannabinoid receptor activation on the post-synaptic membrane. This would explain the experiences of relaxation, tranquillity, and euphoria reported by many paracetamol users, apparently independent of analgesia.

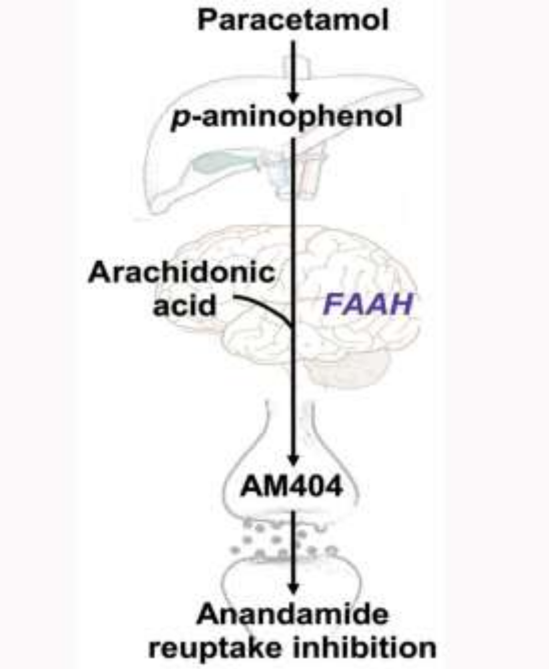

Figure 4: Conversion of paracetamol to AM404, an endocannabinoid reuptake inhibitor.

AM404 appears to be a key player in several pain pathways. Apart from endocannabinoid reuptake inhibition, it has also been shown to activate transient receptor potential vanilloid type 1 (TRPV1) and inhibit cyclooxygenase, NO and tumour necrosis factor-alpha (TNF-α), all involved in acute and chronic pain states. The central production of AM404 would also account for the antipyretic effect of paracetamol, known to be related to inhibition of prostaglandin production in the brain, whilst still without peripheral actions expressed in figure 4.

Adverse effects of paracetamol

Drug interactions

Interaction with a variety of other drugs may occur, and warrant caution in coadministration. For example, concomitant intake of enzyme-inducing substances, such as carbamazepine, phenytoin, or barbiturates, as well as chronic alcohol excess, may increase NAPQI production and the risk of paracetamol toxicity. Concurrent use with isoniazid also increases the risk of toxicity, though as an enzyme inhibitor, the mechanism is not entirely clear.

Concomitant use of paracetamol (4 g per day for at least 4 days) with oral anticoagulants may lead to slight variations in INR values. Increased monitoring of INR should be conducted during the period of concomitant use as well as for 1 week after paracetamol treatment has been discontinued as expressed in table 1.

Table 1: Interaction and Effect on Paracetamol

Sr. No.	Interaction Description	Effect on Paracetamol
1	Paracetamol absorption is increased by substances that increase gastric emptying (e.g. metoclopramide)	Increased absorption
2	Paracetamol absorption is decreased by substances that decrease gastric emptying (e.g. anticholinergic agents, opioids)	Decreased absorption
3	Cholestyramine (ion-exchange resin) reduces the absorption of paracetamol if given within 1 h of paracetamol	Reduced absorption
4	Caution with concomitant intake of enzyme-inducing substances, such as carbamazepine, phenytoin, barbiturates, or isoniazid, may increase the risk of paracetamol toxicity	Increased risk of toxicity
5	Probenecid causes an almost two-fold reduction in clearance of paracetamol by inhibiting its conjugation with glucuronic acid. A dose reduction should be considered	Reduced clearance
6	Salicylamide (analgesic and antipyretic) may prolong the elimination half-life of paracetamol	Prolonged elimination half-life
7	Concomitant use of paracetamol (4 g per day for at least 4 days) with oral anticoagulants may lead to slight variations of INR values	Slight INR variations
8	Paracetamol may also increase chloramphenicol concentrations	Increased chloramphenicol concentrations

CAREER POINT INTERNATIONAL JOURNAL OF RESEARCH
Career Point International Journal of Research (CPIJR)
©2022 CPIJR | Volume 3 | Issue 3 | ISSN: 2583-1895
July-September-2024 | DOI: https://doi.org/10.5281/zenodo.14029572

Toxicity

Although generally safe, potentially fatal kidney, brain, and liver damage may be caused by acute overdose of paracetamol, and in rare individuals, even after a therapeutic dose, attributable perhaps to the presence of subclinical risk factors such as 'fast-metabolizer' status, glutathione deficiency or both.

However, usage within the therapeutic range, particularly frequent regular use, can also impact on other organ systems, with effects that are less widely acknowledged.

Hepatic

Paracetamol toxicity is the foremost cause of acute liver failure and accounts for most drug overdoses in the UK, USA, Australia, and New Zealand. Paracetamol overdose is the most common and predictable cause, but, in certain individuals, hepatotoxicity may occur with doses within the therapeutic range. This may be secondary to deficiencies in glutathione, because of inadequate nutrition, P450 enzyme induction by chronic alcohol excess, or concomitant use of other drugs.

Paracetamol has, in fact, been shown to be well tolerated in hepatocellular insufficiency and even cirrhosis within the normal recommended dose range, albeit cautiously.

Renal

In general, paracetamol is thought to have only minor effects on renal function, of no clinical relevance in most patients. Rare effects have included acute renal failure, acute tubular necrosis, and interstitial nephritis, but these are usually observed after either acute overdose, chronic abuse (often with multiple analgesics), or in association with paracetamol-related hepatotoxicity; that said, acute tubular necrosis has been observed as an isolated finding in rare cases.

There has been equivocal data regarding whether moderate to long-term use may increase the risk of end-stage renal disease. The mechanism of damage is thought, yet again, to involve the depletion of glutathione—a known anti-oxidant, rendering renal cells particularly sensitive to oxidative damage. Optimizing hydration and nutrition status is therefore of specific relevance in those receiving regular paracetamol.

GI effects

Paracetamol can be associated with non-specific gastrointestinal symptoms, such as nausea and vomiting, dyspepsia, abdominal pain, and bloating. In two large studies in patients with musculoskeletal pain, paracetamol was, in fact, associated with more 'digestive adverse effects' than ibuprofen after 6–14 days of regular oral use, though far less than with diclofenac. These effects, however, were mostly abdominal pain and some nausea, and led to no further complications.

Rarely, cases of acute pancreatitis have been reported, and one study has suggested that acetaminophen may precipitate acute biliary pain and cholestasis, possibly related to inhibition of prostaglandin and alterations in the regulation of the sphincter of Oddi.

Haemodynamic changes

Although also rare, hypotension is a recognized adverse effect, listed in the product information of paracetamol. The limited evidence on the subject would suggest that adults and neonates in a critical care setting, who are either febrile or have pre-existing low blood pressure, may have increased susceptibility to a period of hypotension after either enteral or i.v. paracetamol. Whilst often only modest and brief, a proportion of these hypotensive episodes did require supportive intervention, although no long-term sequelae were reported. In adult patients, the hypotension was associated with increased skin blood flow, consistent with its antipyretic action; these effects were not demonstrated in healthy afebrile volunteers, or in elective surgical patients when given paracetamol perioperatively (11,12).

Conversely, regular use of oral paracetamol has been linked with a raised blood pressure. Whilst much of these data come from retrospective observational studies, results from two small randomized, placebo-controlled crossover trials conducted in patients with known coronary artery disease or treated hypertension suggest that after as little as 2 weeks of paracetamol at submaximal doses of 1 g three times a day, heart rate and blood pressure may show statistically, though perhaps not clinically, significant rises.

Respiratory effects

Although most certainly not an NSAID, paracetamol itself may be causally linked with the development of asthma. There has been mounting evidence since 2000 of an association between asthma and paracetamol usage, so strong that it is thought by some to have contributed to much of the dramatic increase in childhood asthma over the past 30 years. The product information for some commercial preparations of paracetamol itself include in their list of possible adverse effects, difficulty breathing, and bronchospasm in patients having a tendency of analgesic asthma.

Aside from its role in detoxifying paracetamol in the liver, glutathione is a pulmonary antioxidant, which may limit airway inflammation in asthma. Consistent with findings in animal and in vitro studies that paracetamol may deplete the lung of glutathione, a plethora of, largely epidemiological, data are strongly suggestive that frequent paracetamol usage may be a direct risk factor for wheezing, rhinitis, and asthma morbidity in adults and children. (13)

Cognitive effects

Paracetamol is almost universally acknowledged as the 'non-drowsy' painkiller, and there is no literature to support claims of associated alterations in consciousness in humans. However, there are many anecdotal reports of euphoria or sleepiness (particularly in children and the elderly—groups in which metabolism may be reduced), after paracetamol, even in the absence of pain or pyrexia.(10) As paracetamol is not a known member of any sedative drug group, these experiences are usually dismissed as because of either placebo effect, co-administration with another drug, or pain-relief allowing the user to relax. However, the mechanism of action of paracetamol remains to be determined; pathways gaining credence include the serotonergic and endocannabinoid systems, both of which are intrinsically involved in consciousness and cognitive function. With this in mind, and on the background of some animal studies that have demonstrated some memory impairment after high-dose paracetamol, this may be an avenue for further research.(14)

Haematological/oncological effects

Thrombocytopenia, leukopenia, and neutropenia are listed as very rare (<1/10 000) adverse-effects. Acute thrombocytopenia has also been reported as having been caused by sensitivity to acetaminophen glucuronide. Methemoglobinemia with resulting cyanosis has been observed in the setting of acute overdose.

Looking at more long-term effects, one prospective cohort study of almost 64 000 men and women aged 50–76 yr showed an association between 'high use' of acetaminophen (defined as use on ≥4 days week−1 for ≥4 yr) and an almost two-fold increased risk of incident haematologic malignancies, that was not shared by NSAIDs. These included myeloid neoplasms, non-Hodgkin's lymphoma, and plasma cell disorders, but not chronic lymphocytic leukaemia or small lymphocytic lymphoma.

Somewhat in contrast to this, a protective effect of paracetamol in the development of ovarian cancer has been suggested. A meta-analysis of eight prospective observational studies to include data from over 746 000 patients showed that 'regular use' (definitions varying from use on 4 or more days each month for more than 6 months, to more than once a day for a year) was associated with a statistically significant 30% reduction in the risk of developing ovarian cancer compared with non-use.

The mechanisms of these proposed effects are unknown, and the role of any number of confounding factors cannot be excluded.

Dermatological effects

Pain or a burning sensation may be experienced at the injection site after i.v. administration and 100 ml volume should be infused over 15 min, but whilst uncomfortable, this is short-lived, and does not preclude further administration. The incidence of hypersensitivity is very rare (<1/10 000), reactions ranging from simple skin rash or urticaria to anaphylactic shock.

A range of other, extremely rare, dermatological effects have been reported, from the nonspecific and transitory, such as erythema, flushing, peripheral oedema and pruritus, to severe, life-threatening conditions such as bullous erythema, purpura fulminans, toxic epidermal necrolysis (TEN), Stevens–Johnson syndrome (SJS), and acute generalized exanthemata's pustulosis.

Headache

Paracetamol is effective in the management of tension-type headache and migraine, though not for cluster headaches. In a meta-analysis of six studies, paracetamol was equianalgesic to low-dose NSAIDs in the treatment of tension-type headache. A combination of paracetamol and caffeine has also been shown to be equivalent to sumatriptan in the acute treatment of migraine.(15)

However, although useful in the treatment of headaches, paracetamol may also contribute to the development of medication overuse headache attributed to excessive ingestion of analgesic agents for relief of other causes of chronic pain, including tension-type headache and migraine. Paracetamol is considered 'overused' when taken on more than 15 days of each month for more than 3 months.

Is paracetamol a sleep-inducing drug?

As a widely available over-the-counter drug, paracetamol is known to be used for purposes other than for its analgesic and antipyretic actions. This include the use of paracetamol for the induction of sleep, which is based on anecdotal personal experiences (16)

It is logical to reason that such sleep promoting action by paracetamol is a consequence of improvement of the patients' pain experience or is merely a placebo effect. Pilot-controlled clinical trials failed to demonstrate a positive correlation between paracetamol administration and improvement of sleep(17-19).

Considering the thermoregulatory actions of paracetamol are believed to be mediated through inhibition of PGE2 within the hypothalamus, it is thought provoking to reason that paracetamol might have mild sleeping inducing properties, particularly when bearing in mind the fact that PGE2 is known to induce wakefulness(20-22) inhibition of which would promote sleepiness. It is feasible to believe that paracetamol affects common neuronal circuitry mechanisms within the hypothalamus that regulate sleep and body temperature, a paradigm that would be worth further investigation (Reference 23 provides an overview on the CNS neural circuitry and role of prostaglandins in the development of sickness syndrome/behavior that includes fever and increased sleepiness). Indeed, the suprachiasmatic nucleus within the anterior medial zone of the hypothalamus is known to be involved in circadian control of sleep-wake cycle and body temperature.

Final remarks and future considerations on paracetamol

Owing to the fatal hepatotoxicity associated with paracetamol over-dose [24,25], it has been debated whether paracetamol should be withdrawn from the market or to be reclassified. At therapeutic dose paracetamol is a safe drug, but with a narrow therapeutic window, it is easy to accidently or deliberately over-dose. Such debates between clinicians, scientists and drug regulators have been ongoing for some time with the general population rarely being involved in such dialogs. It is predicted that withdrawal of paracetamol from global markets or even its re-classification would not be well received by the general population. As on over-the-counter, most people self-medicate with paracetamol for the management of acute/mild pain and fever. Paracetamol became particularly important during the current global SARS-CoV-2 pandemic as ibuprofen, another over-the-counter analgesic antipyretic drug, was initially contraindicated for these patients [26], a notion that was later rejected [27,28]. Undoubtedly, paracetamol holds a

Career Point International Journal of Research (CPIJR)
©2022 CPIJR | Volume 3 | Issue 3 | ISSN: 2583-1895
July-September-2024 | DOI: https://doi.org/10.5281/zenodo.14029572

unique place as a familiar and widely used analgesic antipyretic drug which for many decades has puzzled pharmacologists in regards to its mechanism of pharmacological actions (Prevailing theories on the mechanisms of pharmacological actions discussed in this review are summarized in Figure 5). From a clinical perspective, withdrawal of paracetamol from the market would leave a void for the management of mild pain and fever whether through physicians' recommendation or patients' own self-medication endeavors and the search for a drug to replace paracetamol may be the way ahead, but equally not necessarily provide a safer alternative. It is worth remembering that a wealth of knowledge on the paracetamol-induced toxicity has accumulated over the many decades of clinical use. Several measures have been put in place to help reduce the paracetamol-induced toxicity that include limits on package size, which has had limited impact [29,30].

Therefore, more steps to help prevent overdosing with paracetamol are needed. Such steps may include helping to provide general awareness on the risks linked to overdosing with paracetamol [31-33]. From a pharmacological perspective, the search for the molecular target for paracetamol continues, which may provide us with a new way to treat pain and fever in the future.

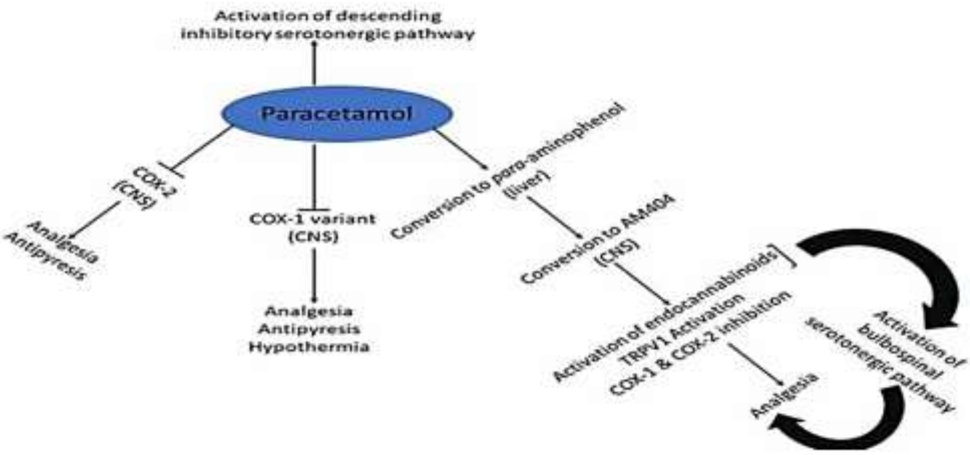

Figure 5. Theories on paracetamol's pharmacological mechanisms.

Conclusion

Paracetamol remains one of the most widely used and accessible over-the-counter analgesics with a favorable safety profile at therapeutic doses, emerging evidence reveals potential adverse effects, particularly with chronic use. These effects include increased risk of gastrointestinal bleeding, elevated blood pressure, and possible cardiovascular, renal, and respiratory impacts. Additionally, recent studies highlight concerns over in utero exposure and possible long-term effects on development. It is crucial for healthcare providers to carefully weigh the benefits and risks when recommending prolonged paracetamol use, especially in populations vulnerable to its adverse effects. Further research is needed to fully elucidate these risks and refine guidelines for safe usage.

Notes on contributors

Dr. M. K. Gupta, Dr. Girish Kumar Vyas, Dr. Nitin Nama, Me. Rahul Ancheria Supported me a lot for the guidance and writing this paper.

References

1. Von Mering J. Beiräge zur Kenntniss der Antipyretica. Therap Monatsch. 1893;7:558–577.
2. Brodie BB, Axelrod J. The fate of acetophenetidin (phenacetin) in man and methods for the estimation of acetophenetidin and its metabolites in biological material. J Pharmacol Exp Ther. 1949;97:58–67.
3. Schrör K. Aspirin and Reye syndrome: a review of the evidence. Paediatr Drugs. 2007;9(3):195–204.
4. Prescott LF. Paracetamol: past, present and future. Am J Ther. 2000;7:143–147.
5. Leung L. J Prim Health Care. 2012;4:254.
6. Ji P, Wang Y, Li Z, Doddapaneni S, et al. J Pharm Sci. 2012;101:4383.
7. Howard SS. Pain Physician. 2009;12:269.
8. Mattia C, Coluzzi F. What anesthesiologists should know about paracetamol (acetaminophen). Minerva Anestesiol. 2009;75:644–653.
9. Smith HS. Potential analgesic mechanism of acetaminophen. Pain Physician. 2009;12:269–280.
10. Bertolini A, Ferrari A, Ottani A, Guerzoni S, Tacchi R, Leone S. Paracetamol: new vistas of an old drug. CNS Drug Rev. 2006;12:250–275.
11. Allegaert K, Naulaers G. Haemodynamics of intravenous paracetamol in neonates. Eur J Clin Pharmacol. 2010;66:855–858.
12. Boyle M, Nicholson L, O'Brien M, et al. Paracetamol induced skin blood flow and blood pressure changes in febrile intensive care patients: an observational study. Aust Crit Care. 2010;23:208–214.

13. Eneli I, Sadri K, Camargo CJr, Barr RG. Acetaminophen and the risk of asthma: the epidemiologic and pathophysiologic evidence. Chest. 2005;127:604–612.
14. Ishida T, Sato T, Irifune M, Tanaka K, Nakamura N, Nishikawa T. Effect of acetaminophen, a cyclooxygenase inhibitor, on Morris water maze task performance in mice. J Psychopharmacol. 2007;21:757–767.
15. Pini LA, Guerzoni S, Cainazzo M, Ciccarese M, Prudenzano MP, Livrea P. Comparison of tolerability and efficacy of a combination of paracetamol+caffeine and sumatriptan in the treatment of migraine attack: a randomized, double-blind, double-dummy, cross-over study. J Headache Pain. 2012;13:669–675.
16. Sproule BA, Busto UE, Buckle C, et al. The use of non-prescription sleep product in the elderly. Int J Geriatr Psychiatry. 1999;14(10):851–857.
17. Murphy PJ, Badia P, Myers BL, et al. Nonsteroidal anti-inflammatory drugs affect normal sleep patterns in humans. Physiol Behav. 1994;55(6):1063–1066.
18. Baker FC, Driver HS, Paiker J, et al. Acetaminophen does not affect 24-h body temperature or sleep in the luteal phase of the menstrual cycle. J Appl Physiol. 2002;92(4):1684–1691.
19. Van De Glind EM, Hooft L, Tulner LR, et al. Acetaminophen for self-reported sleep problems in an elderly population (ASLEEP): a randomized double-blind placebo-controlled trial. Int J Geriatr Psychiatry. 2016;31(8):955–957.
20. Matsumura H, Goh Y, Ueno R, et al. Awaking effect of PGE2 microinjected into the preoptic area of rats. Brain Res. 1988;444(2):265–272.
21. Hayaishi O. Molecular mechanisms of sleep-wake regulation: roles of prostaglandins D2 and E2. FASEB J. 1991;5(11):2575–2581.
22. Matsumura H, Honda K, Choi WS, et al. Evidence that brain prostaglandin E2 is involved in physiological sleep-wake regulation in rats. Proc Natl Acad Sci U S A. 1989;86(14):5666–5669.
23. Saper CB, Romanovsky AA, Scammell TE. Neural circuitry engaged by prostaglandins during the sickness syndrome. Nat Neurosci. 2012;15(8):1088–1095.
24. Tittarelli R, Pellegrini M, Scarpellini MG, et al. Hepatotoxicity of paracetamol and related fatalities. Eur Rev Med Pharmacol Sci. 2017;21(1):95–101 Suppl.

25. Smilkstein MJ, Knapp GL, Kulig KW, et al. Efficacy of oral N-acetylcysteine in the treatment of acetaminophen overdose. Analysis of the national multicenter study (1976 to 1985). N Engl J Med. 1988;319(24):1557–1562.
26. Day M. Covid-19: ibuprofen should not be used for managing symptoms, say doctors and scientists. BMJ. 2020;368:m1086.
27. Moore N, Carleton B, Blin P, et al. Does Ibuprofen Worsen COVID-19? Drug Saf. 2020;43:611–614.
28. Sridharan GK, Kotagiri R, Chandiramani VH, et al. COVID-19 and avoiding ibuprofen. How good is the evidence? Am J Ther. 2020;27(4):e400–e402.
29. Hawkins LC, Edwards JN, Dargan PI. Impact of restricting paracetamol pack sizes on paracetamol poisoning in the United Kingdom. Drug Saf. 2007;30(6):465–479.
30. Bateman DN. Pack size and paracetamol overdose: 16 years later. Clin Toxicol (Phila). 2014;52(8):821–823.
31. Shah AD, Wood DM, Dargan PI. Internet survey of home storage of paracetamol by individuals in the UK. QJM. 2013;106(3):253–259.
32. McNicholl BP. Toxicity awareness and unintended suicide in drug overdoses. Emerg Med J. 1992;9(2):214–219.
33. 33. Hawton K, Ware C, Mistry H, et al. Why patients choose paracetamol for self-poisoning and their knowledge of its dangers. BMJ. 1995;310(6973):164


Providing The Best Placement to all Students
3000+ RECORD BREAKING PLACEMENTS SO FAR
66 Lakhs Highest CTC Achieved
350+ Companies Visited
Few of CPU Students Working in Top Corporate
B.Tech-CSE
SAMSUNG
Deloitte
BCA
Canada
Germany
MCA
MBA
PULSE
Collabera
NOVATR
RIVOLTA Italy
jaro education
HCL
Few of CPU Students in Government Sector
Sangeeta Meena
LLB
Anjali Ahmed
M.Sc Agriculture
Manoj Kumar
M.Sc Agriculture
Dinesh Meena
B.Sc - B.Ed
Hemraj Meena
B.Sc - B.Ed
Rahul Kumar
B.Sc - B.Ed
Abhishek Singh
B.Sc - B.Ed
Our Students with Multiple Job Offers
Infosys
Collabera
Successful Startups by CPU Students
Murtaza
B.Tech (CSE)
Startup:
Samtec Limited
Abhinandan Gupta
BBA
Startup:
Hemant Rathor
BCA, MCA
Start up:
Device Doctor
Yashraj Sahu
B.Sc Agriculture
Startup:
A1 Mashroom
CAREER POINT UNIVERSITY
City Office: CP Tower - 1, Road No - 1, IPIA, Kota | University Campus: Alaniya, Jhalawar Road, Kota | 080-69662305 | www.cpur.in