CONSUMPTION OF FERTILIZER AND PESTICIDES IN TELANGANA: SMALL AND MARGINAL FARMERS' CHALLENGES

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Abstract: The industrialization of agriculture has favoured the use of plenty of agrochemicals including fertilizers, pesticides, micronutrients. Consumption of pesticides has become an integral part of modern agriculture and is an effective and economical way to enhance the yield quality and quantity. Approximately, 2 million metric tons (MT) of pesticides are utilized annually worldwide. India stands 12th in pesticide use globally and 3rd in Asia after China. India shares only 1% of the global pesticide use. After the green revolution, there is increased use of chemical pesticides which resulted in contaminating the environment and the long-term implications on the society. Indiscriminate and excessive application of pesticides not only have damaged the environment but also have entered the food chain thereby affecting health and development. However, the role of pesticides in augmenting agricultural output has been well perceived and these have been considered as essential inputs in agricultural production. The present paper aimed to study the consumption pattern of pesticides and fertilizers among the small and marginal farmers. This study also aimed to know the farmers' knowledge about the safe handling and application of pesticides and their practices on pesticide usage. While doing so, it highlights some issues like change in the cropping pattern among small and marginal farmers and also emphasizes on soil degradation and environmental issues.

Keywords: sustainable agriculture, pesticides, fertilizers, landholdings, Telangana.

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INTRODUCTION

India's agriculture has historically been marked by significant advancements, yet it has also endured periods of food scarcity that profoundly affected its civilization. Prior to independence, agricultural success in India was heavily contingent on climatic conditions. Unfavourable climatic conditions led to droughts and crop failures, often resulting in famines. Serving as the bedrock of livelihoods, civilization, culture, and heritage in India, agriculture remains of paramount importance. Approximately half (about 160 million hectares of arable land) of its total geographical area is dedicated to cultivation, positioning it as one of the world's top agricultural land users (Pathak et al. 2022). Over the years, food grain production has surged from 51 million tons in 1950-51 to over 314 million tons in 2021-22. Despite numerous achievements, India's agriculture faces new challenges. Indian agriculture, among the oldest systems globally, exhibits diversity, heterogeneity, and organizational complexity, often subject to uncertainties from "seed to market". India's agricultural landscape has long been characterized by diversity, stemming from a blend of various agro-ecological zones and cultural plurality. India encompasses all 15 prominent climates and 46 out of 60 soil types found globally. It stands as a critical sector for the country's sustainable and inclusive economic growth. The expanding population and evolving economies have escalated demand for high-quality diversified food, while rising input costs, machinery expenses, and labour charges have eroded profitability, rendering farming less attractive as a livelihood or preferred profession (Pathak et al. 2022; Jodhka 2014).

Till 1960s, the methods of farming were largely traditional, the farming communities were involved in the whole process of agriculture like seed conservation, breeding and selection, etc. With the advent of green revolution there is a drastic shift in agriculture, i.e. from subsistence farming to commercial farming, which is increasing the marketed surplus and causing a shift towards cultivating high value crops. Green revolution may be considered as the epicentre for radical changes in rural India resulting unprecedented changes in the agrarian social

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structure. The period spanning from 1967 to 1980 witnessed a transformative era in agricultural practices. This revolution saw a departure from traditional methods towards the adoption of high-yielding variety (HYV) seeds and chemical fertilizers. These HYV seeds demonstrated remarkable responsiveness to fertilizers, leading to a significant increase in yields per unit of fertilizer applied. As a result, agriculture underwent a comprehensive overhaul, encompassing mechanization, marketization, capitalization, chemicalization, commercialization, modernization, and a pivot towards information-driven practices (Naveen 2015; Wani et al. 2021). Notably, the commercialization of agriculture gained momentum during this period, especially among small and marginal farmers. They were drawn towards cultivating cash crops like cotton, maize, and soybeans primarily for market sale rather than solely for subsistence purposes. Various inputs such as chemical fertilizers, pesticides, weedicides, and mechanical implements like tractors, weeders, and harvesters became integral components of the green revolution. These technologies enabled farmers to enhance productivity, streamline operations, and transition towards more efficient and commercially viable agricultural practices. Overall, the green revolution technology proved to be a compelling catalyst for small and marginal farmers, facilitating their transition from subsistence farming to market-oriented cultivation now (Kayatz et al. 2019).

In India, small land holdings (fig. 1) are a prominent feature, particularly in rainfed regions. 80% of farmers' holdings are ≤ 2 ha, accounting for >50% of agricultural output. The small and marginal holdings taken together (0.00-2.00 ha) constituted 86.08% of the total land holdings in 2015-16. And small and marginal holding farmers cultivate around 44% of the area, and they produce around 60% of the total food grain production (Agriculture Census 2015-16). As per the Land Use Statistics 2018-19, the total geographical area of the country is 328,7 million hectares, of which 139,3 million hectares is the reported net sown area and 197,3 million hectares is the gross cropped area with a cropping intensity of 141.6%. The net area sown works out to be 42.4% of the total geographical area. The net irrigated area is 71,6 million (Promodita 2022). From the above

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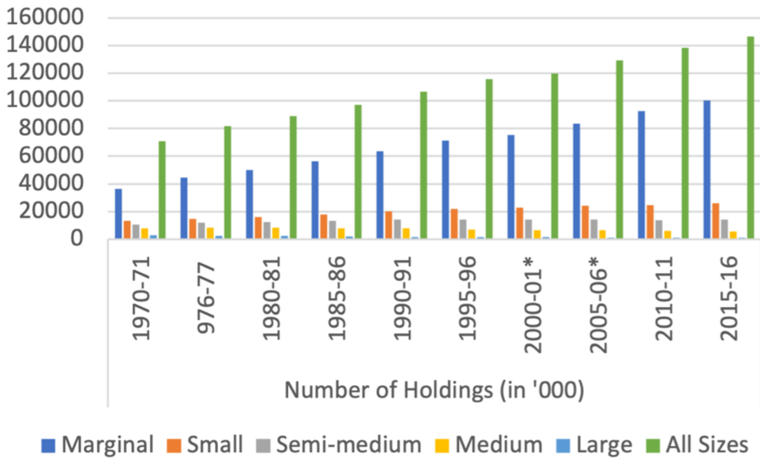

Fig. 1. *Size of Land Holdings since 1970-2016.*

discussion it is noted that green revolution witnessed the spread of commercial agriculture, where the small and marginal farmers started cultivating cash crops like cotton, maize, and soybeans. Cotton is one of the most important fibre and cash crops of India and plays a vital role in sustaining the livelihood of an estimated 6 million cotton farmers and 40-50 million people engaged in related activity such as cotton processing and trade. India has emerged as the largest producer of cotton in the world and occupies the first position in terms of total area and production and accounts around 25% of the total global cotton production. The area under cotton in the current year (2022-23) in the country increased from 12,372 million to 13,04 million hectare estimated to 5.5% increase in year 2023-24.

India got 1st place in the world in cotton acreage with 12,069 million hectares area under cotton cultivation i.e. around 36% of world area of 33,3 million hectares. Among the major Cotton exporting countries in the world, India occupied 3rd position with 5,5 million bales. As increase in the area under cotton (fig. 2), the production also increased to the tune of 8.4% (from 31,1 to 33,7 million bales). On the productivity front, a marginal increase from 428 to 439 kg per hectare in the current year compared to last year (Pocket Book of Agricultural Statistics 2017; USDA 2020-21).

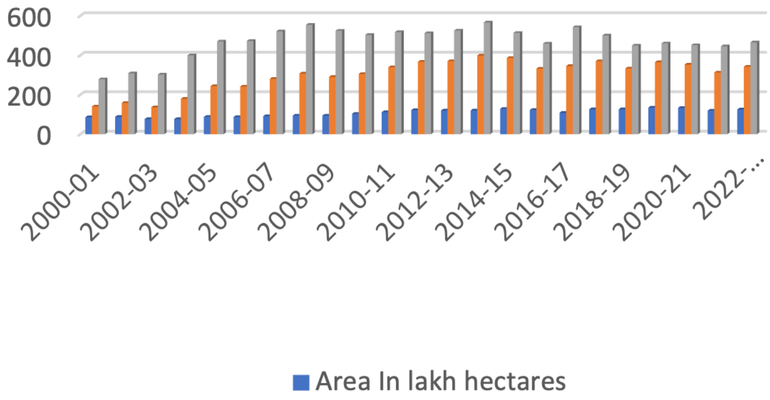

Fig. 2. *Area, production and productivity of cotton in India from 2000-01 onwards.*

Source: Meeting of Committee on Cotton Production and Consumption (COCPC) held on 15 November 2022.

Production in India during 2017-18 was 37,7 million bales from 12,2 million hectares with a productivity of 525 kg lint/ha (Cotton Association of India 2019). Nearly two thirds of the cotton production in India comes from the states of Maharashtra, Gujarat, Andhra Pradesh, and Telangana, covering around 71% (8,64 million hectare) in area under cotton cultivation and 65% (24,6 million bales) of cotton production in India. Procurement of cotton was highest in Telangana and Maharashtra. Cotton is the third most important commercial crop being cultivated in 11 million ha, with an irrigation cover of about 37%. Total water consumed, based on ET, in cotton production in India is 51,11 km. As on 17 September 2021, area under cotton during 2021-22 was 11,96 million ha as against 12,69 million ha in 2020-21 as compared to the previous year (Centre for Agriculture and Rural Development Policy 2022).

METHODOLOGY

The present study aimed at understanding the perceptions and consumption pattern of pesticides and fertilizers among

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small and marginal farmers. This study also tries to understand the challenges facing by small and marginal farmers in adopting the scientific/substantiable agriculture. The study was conducted in Adilabad district of Telangana State. This district was purposively selected for the study. Cotton is widely cultivated in Maharashtra, Gujarat and Telangana regions, whereas Telangana stands in the 3rd position in cotton production. Cotton is popularly called as "white gold" and is grown in most of the parts of Telangana. Each year cotton is cultivated in about 1,25 million hectares with a production of 4,88 million bales (Indian Council of agricultural research 2022-2023).

According to the census of landholdings (2015-16), there are 5,94 million landholdings in Telangana covering a total area of 14,756 million acres. Marginal farmers (<2.47 acres) hold 64.6% of the landholdings, accounting for 28.6% of the area operated. Small farmers (2.48-4.94 acres) hold 23.7% of the total landholdings, accounting for 33.1% of the area operated. Semi-medium farmers (4.95-9.88 acre) hold 9.5% of the total landholdings, accounting for 24.6% of the area operated. Medium farmers (9.89-24.7 acre) hold 2.1% of the total landholdings, accounting for 11.5% of the area operated. Large farmers (>24.7 acres) hold 0.2% of total landholdings, accounting for 2.3% of the area operated (333.6 acres).

In Telangana, the area under cotton cultivation is likely to increase by at least 20% to 1,75 million hectares during the current kharif season, compared to the fibre grown on 1,41 million hectares last year. Marginal and small farmers hold about 88.3% of the landholdings (less than 4.94 acres) accounting for 61.7% (3,68 million hectares) of the area operated. Cotton is an important fibre crop cultivated majorly in Nalgonda, Adilabad, Nagarkurnool, Asifabad, Vikarabad and Khammam districts of Telangana state and cultivated nearly in 5 million acres (Telangana Socio Economic Outlook 2023). Adilabad district (Telangana state) is located in the northern end of the state bordering the state of Maharashtra. The total geographical area of the district is 1,6105 sq. mi. Agriculture is the main stay of the economy of Adilabad district. The main crops grown in the district are rice, maize, cotton and soyabean. The gross cropped area of the district is 654,000 ha and the gross irrigated area is 210,624 ha.

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Climate and soils in Adilabad district of Telangana are favourable to grow Bt cotton crop. Cotton occupies an important place in the agriculture sector of this district. Adilabad has got 27% area under cotton in all the Telangana districts put together and 16% of the area under cotton in the entire state. Adilabad is also known as city of cotton (Telangana State Statistical Abstract 2021).

From two revenue divisions, namely Adilabad and Nirmal, two blocks were selected from this district, on the basis of allocation of highest area to cotton crop. From each block one village was selected purposively (Thamsi and Neradigonda from Adilabad where as Bhainsa and Kubeer from Nirmal were selected randomly). The agricultural households were completely enumerated in respect of allocation of land for cotton cultivation by the farmers. 104 farmers are selected for the interview by using the technique of Simple Random Sampling. Out of these 104 farmers, 44 farmers were marginal (<1 ha), 35 farmers were small (1-2 ha), 22 farmers were medium (2-10 ha), and 3 farmers were large (>10 ha). Both qualitative and quantitative research methods were used to analyse the data. This study was based on primary data and secondary data were also used when necessary. Data were collected based on land allocated to cotton crop, quantity of different types of inputs used by the farmers, cost of inputs, production and productivity of cotton, price of the product, etc.

CONSUMPTION OF FERTILIZERS AND PESTICIDES

Pesticides and fertilizers are integral components of modern agriculture, playing a crucial role in mitigating crop losses, increasing yields, and enhancing food affordability and quality. Farmers rely on pesticides, including insecticides, fungicides, and herbicides, to manage weeds and pest infestations, leading to significant improvements in agricultural output. In India, insecticides account for the largest share of pesticide consumption, although the country only represents 1% of global pesticide use. India utilized approximately 58,160 MT of pesticides in 2018, with a per-hectare application rate of only 0.31 kg in 2017 (Dhaliwal et al 2015).

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The production of pesticides started in India in 1952, with the production of benzene hexachloride, followed by DDT. India is now the second largest manufacturer of pesticides. The synthesis of pesticides increased enormously over a period. In 1958, India manufactured over 5,000 MT of pesticides which increased to 102,240 MT in 1998 with the registration of 145 pesticides and the major pesticides produced are insecticides. India is one of the major pesticides producing countries in Asia with annual production of 90,000 MT, and it stands at twelfth position in the world in the manufacturing of pesticides. In the year 2022-23, urea accounts for more than half of the total fertilizer production (58.4%) total consumption (57.9%), and 35.9% of imports (Gupta 2004; Khan 2010).

In India, the pesticides are broadly divided into five types which are used in agriculture, pesticides are classified by different targets of pests, including fungicides, insecticides, herbicides, and rodenticides. For example, fungicides are used to kill fungi, insecticides are used to kill insects, while herbicides are used to kill weeds. Insecticides cover the major part i.e. 60% of the market share, whereas Fungicides 18%, Herbicides 16% and the rest 6% by others. Bio-pesticides are an emerging category and are currently a small proportion of the market but have a huge growth potential considering its non-toxic nature. The consumption of insecticides in 1999-2000 was 60%, fungicides 21%, herbicides 14% and others 5% (Sharma et al. 2019).

The fertilizer consumption in India (fig. 3) rose from 1.0 kg. per hectare in 1956-57 to 7 kgs per hectare in 1966-67. Subsequently, it reached 46.4 kgs per hectare in 1984-85. Urea consumption witnessed a rise, increasing from 295,65 MT in 2011-12 to 357,25 MT in 2022-23. Similarly, DAP usage experienced an uptick from 101,91 MT to 105,31 MT during the same period. In contrast, MOP consumption declined from 30,29 MT in 2011-12 to 16,32 MT in 2022-23. The recommended ratio use of NPK fertilizers is 4:2:1, but this ratio in India is currently at 6.7:2.4:1. The consumption of agrochemicals in India for the year 2020-21 has been 62,192.63 MT (technical grade) (Ansari, Sheereen 2022). Moreover, the consumption of major fertilizers in the state has seen a notable increase, escalating from 2,88 million MT in 2018-19 to 3,7 million MT in the fiscal year 2021-22. Similarly,

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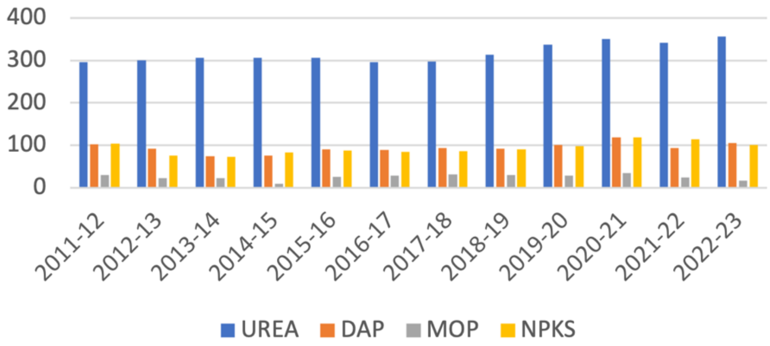

Fig. 3. *Consumption of chemical fertilizers in India.*

Source: Rajya Sabha 2020-21 is up to February 2021.

in Telangana State also the fertilizer consumption has increased from 0,24 million MT in 1985-86 to 1,1 million MT in 2014-15. The utilization of NPK increased from 247.6 kgs per hectare to 256.6 kgs between 2015-16 and 2019-20 (Devi, Suhasini 2017). It is opined that, with the introduction of green revolution, the consumption of fertilizers and pesticides increased unprecedently because the HYV seeds are highly responsive to fertilizers. However, the use of toxic chemicals has also led to adverse effects, including the decline of plant biodiversity, environmental pollution, reductions in the water table and water quality, as well as overall soil health depletion (Tudi et al. 2021).

CHALLENGES

The primary aim of introducing pesticides was to effectively manage and control insect pests and diseases impacting field crops. Despite the undeniable benefits of increased food production, facilitated by the widespread usage of pesticides and fertilizers, the country has experienced notable achievements in cotton production, achieving self-sufficiency in this sector. But, the indiscriminate and improper application of chemicals and pesticides has resulted in land degradation, adverse health effects, environmental and societal contamination. Annually, approximately 5,3 billion MT of soil are eroded, equating to a rate of about 16,4 MT per hectare. The total area of degraded land increased to 96,59 million hectares, constituting 29.32% of the total geographical area, in the period of 2011-13, up from approximately 94,53 million hectares in 2003-05 (SAC 2016). The UN Food and Agriculture Organization estimates that in developing countries, pests, weeds and disease destroy about 40% of crops while they are still in the fields and 6 to 7% of them after the harvest. Some estimates project that 35-45% crop production is lost due to insects, weeds and diseases, while 35% crop produces are lost during storage (Dhaliwal et al. 2015). Agriculture, responsible for 70% of global water usage, significantly contributes to water pollution. Farms release substantial amounts of agrochemicals, organic matter, drug residues, sediments and saline drainage into water bodies. This pollution poses proven risks to aquatic ecosystems, human health, and various productive activities. India has the highest demand for freshwater usage globally, and 91% of water is used in the agricultural sector now. It is opined that the growth of operational landholdings and small and marginal farmers is also one of the major factors that affects the water consumption (UNEP 2016; Rodriguez et al. 2020).

According to the study conducted by Central Soil Water Conservation Research and Training Institute (CSWCRTI), India is losing massive amounts of fertile agricultural land every year. About 5,334 million MT of soil is eroded because of indiscreet and excess use of fertilizers, insecticides and pesticides. It is estimated that it takes nearly 2,000 years for nature to produce a 10-centimeter (4-inch) layer of fertile soil that holds water and nutrients, and where plants can grow (Joshi et al. 1996; Das 2022). While the risks of pesticide exposure are prevalent across all segments of the population, individuals directly involved in the production centres, supply chain processes, and end-users such as farmers and farm workers are particularly susceptible to higher levels of direct exposure (Jeyaratnam 1990; Devi 2010). In India, estimated annual production losses due to pests are as high as USD 42,66 million. It is believed that only about 0.1% of pesticides reach their intended targets, leading to widespread environmental pollution and land degradation

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(Peshin et al. 2016). On average, pests and diseases in India consume 15-25% of food produce annually. The country suffers crop losses of over Rs 6,000 crores per year due to pests, with 33% attributed to weeds, 26% to diseases, 20% to insects, 10% to birds and rodents, and the remaining 11% to other factors (Roberts et al. 2017).

It's widely acknowledged that the utilization of fertilizers and pesticides is influenced by a multitude of factors including cultivated land area, crop varieties, rotation practices, soil health, agro-climatic conditions, financial resources of farmers, irrigation availability, and other relevant considerations. In many developing countries, farmers often lack sufficient knowledge in handling pesticides properly, resulting in deviations from best agricultural practices. Pesticide application is commonly perceived as an economic, labour-saving, and effective method for pest management and increasing crop yields. Research consistently indicates that farmers prioritize the use of fertilizers and pesticides to maximize crop production. Consequently, farmers, whether knowingly or unknowingly, have become reliant on agrochemicals, contributing to ecosystem pollution and unintended harm to non-target species (Tudi et al. 2021).

DISCUSSION

Agricultural productivity depends on several factors which includes the availability and quality of agricultural inputs such as land, water, seeds and fertilizers, access to agricultural credit and crop insurance, assurance of remunerative prices for agricultural produce, and storage and marketing infrastructure. Soil assumes the prime concern in agriculture and one of the most important factors in increasing the productivity of agriculture, but soil degradation is increasingly becoming a major concern for Indian agriculture on which two thirds of the population depends for their livelihood (Bhattacharyya 2015).

Cotton and paddy are the major crops where pesticides consumption is 50% and 18% respectively. Cotton covers only 5% of the cropped area, but accounts for 50% of pesticide use. Rice, which is grown over 24% of the cropped area, consumes 18% of the pesticides. Data shared by the government indicates that the consumption of chemical fertilizers has increased by around

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16% between 2015-16 and 2020-21 from about 510 LMT in 2015-16, the consumption increased to 590 LMT as per provisional figures for 2020-21 (Abhilash 2009).

It is evident from the figures 4 and 5 that the use of Herbicides in cotton in the study area was higher in case of Pendimethalin (3.20 l/ha) followed by Quizalofop-P-ethyl 10% EC (1073.19 grams/ha), Propaquizafop 10% EC (718.65 ml/ha) and lowest in case of Pyrithiobac Sodium 10% EC (644.74 ml/ha). The above herbicides were used for controlling pre-emergence herbicides, Dactyloctenium aegypticum, Cynodon, Echinochloa colonum, Dactyloctenium aegypticum, Trianthema portulacastrum, Acalypha indica, Abutilon indicum, Euphorbia.

Consumption of fertilizers and pesticides is determined by multiple factors such as area of land under cultivation, the type of crop, cropping pattern and cropping intensity, soil type and its condition, agro-climatic conditions, the ability of farmers to purchase, irrigation, and others. It is evident from the figure 5 that the use of insecticides in cotton in the study area was higher in case of Chloripyriphos 20% EC (154.66 ml/ha) followed by Profenophos 50% EC (1058.81 ml/ha), Acephate 75 (759.26 gra grams/ha), Emamectin benzoate 5% SG (227.08 grams/ha), Imidacloprid 200% SL (165.73 ml/ha) and lowest in case of Chlorantraniliprole 18.5% SC (154.66 ml/ha). The above insecticides were used for controlling tobacco cutworm, cotton aphid, fruit borer, pink bollworm, cotton white flies, cotton thrips. From figures 4 and 5, it is ascertained that, the consumption of fertilizers and pesticides by small and marginal farmers are relatively high when compared with the large farmers and it is observed that majority of the farmers switching to commercial crops like cotton and maize and given up cultivating traditional crops like pulses and cereals because to gain maximum profits and the consumption of water is low for the cotton when camped to the others crops like paddy. It is observed that majority (90%) of the farmers are literate and engaged in the farming since decades, but they are not aware of sustainable farming practices. It is found that farmers are unable to access the appropriate and timely information. Due to lack of scientific information farmers are using the fertilizers and pesticides beyond recommended ratio, which is leading to increase in the input cost and soil degradation.

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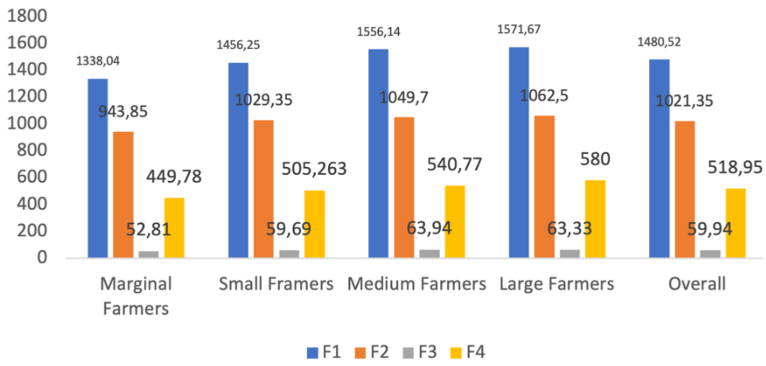

Fig. 4. *Use of fungicides in cotton*.

Source: Field work 2019-2020. F denotes the Name fungicide, F1 denotes Copper Oxychloride 50% EC, F2 denotes Carbendazin 12% + Mancozeb 63% WP, F3 denotes Streptocycline and F4 denotes Tebuconazole + Trifloxystrobin.It is noted that farmers use the fungicide grams per hectare (gm/ha).

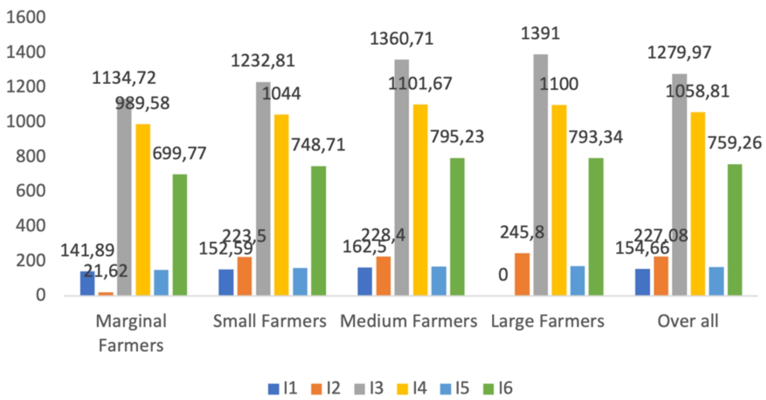

Fig. 5. *Use of insecticide in cotton*.

Source: Field work 2019-2020. the name insecticide, I1 denotes Chlorantranil iprole 18.5% SC, I 2 denotes Emamectin benzoate 5% SG, I 3 denotes Chlorpyriph os 20% EC, I4 Profenofos 50% EC, I5 denotes Imidacloprid 200% SL insecticide and I6 acephate 75 sp. It is noted that, I1, I4, I5, are measured in terms of milliliter per hectare (ml/ha) whereas I2, I3 and I6 are measured in terms of grams per hectare (gms/ha).

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STATE'S INTERVENTION IN FUNDING AND FACILITATING AGRICULTURAL EXTENSION SERVICES

After the 1991 reforms state funding towards agricultural sector is reduced drastically and agricultural extension services become paralyzed which played a crucial role in transferring technology during green revolution period. The decline in the public agricultural extension services has led to the growing influence of input dealers and agents of various national and international agribusiness companies. One of the important observations is that, about 97% of farmers are approaching input dealer for agricultural information. The study finds that input dealer has emerged as the key source of information. Farmers reported that they approach the input dealers because they are available for most part of the day, approachable for all sections of farmers and they provide quick response (Naveen 2015).

Even though most of the farmers are literate still they access information from unreliable sources. One of the major observations is that the farmers think that high usage/dosage of pesticides will give maximum output. Farmers opined that cotton is one of the major commercial crops which gives maximum profit because the application of chemical fertilizers and pesticides is high. Pesticides are often considered a quick, easy, and inexpensive solution for controlling weeds and insects. It is also observed from the above tables that farmers are using the heavy dosage of pesticides, and they are not following/applying the prescribed dose of pesticides. Overall, in today's globalized agricultural industry, access to information, adherence to expert advice, and adoption of sustainable practices are critical for farmers to thrive in the competitive market while ensuring the long-term viability of their operations.

It is also observed that over usage of fertilizers/pesticides is leading the damage of the crop and increasing in the input cost and unnecessary usage of pesticides reduces the quality of cotton. As a whole, cost of cultivation was found to be rupees 5,200 (approx.) per acre, whereas the price per quintal is about 7,000 (approx.). It is opined by the farmers, that input cost like land preparation seeds and sowing, manures and manuring, labour cost is increased extremely over a period. One of the important findings is that majority of the small and marginal farmers are also using tractors and other machinery for the tilling land. For the small and marginal farmers bearing the cost of machinery is burden. This is one the reason why small and marginal farmers unable to reap the maximum profits. Due to limitations in their financial resources, marginal and small-scale farmers struggle to invest more in the cultivation of this crop.

In today's globalized market economy, access to information has become indispensable in agriculture. The challenges posed by expensive, imperfect, and asymmetric information are manifold for farmers, including heightened marketing risks, inefficient resource allocation, increased transaction costs, and suboptimal marketing decisions. Addressing information constraints to enhance market efficiency, particularly for marginalized groups, is a significant challenge. However, in India, farmers' lack of proper organization stems from factors such as limited awareness, education, and social barriers. Additionally, ineffective information dissemination channels and inadequate government oversight have allowed numerous private entities to promote agricultural information biased toward their interests which leads to monopolization of agriculture. These private entities are highly concerned with profit rather sustainability.

CONCLUSION

It is widely noted that due to over usage of fertilizers and pesticides by farmers, agriculture sector has become one the key contributor of pollution and soil degradation. 21st century known for sustainable growth and development; in this regard structural and functional reforms within agricultural extension services are essential to effectively meet the diverse needs of farmers. Thus, access to accurate and timely information is crucial for farmers to optimize their output and remain competitive in the global market. With the opening up of the agricultural sector as part of globalization, Indian farmers are not only competing locally but also globally, which places even greater emphasis on the need for efficiency and productivity. Following the advice of agricultural scientists and officers is paramount for farmers to enhance their

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productivity. These experts can provide valuable insights into best practices, optimal crop varieties, and suitable agricultural techniques that can significantly improve yields. Moreover, the timely application of fertilizers and pesticides in appropriate doses is essential for maximizing productivity while minimizing costs and environmental impact. Overuse or underuse of these inputs can lead to reduced yields, increased expenses, and environmental degradation. Therefore, farmers must stay informed about the latest recommendations and advancements in agricultural inputs and practices. Furthermore, exploring alternatives to chemical fertilizers and pesticides can offer several benefits, including cost reduction and environmental sustainability. Organic farming methods, integrated pest management (IPM) techniques, and the use of biofertilizers are some examples of alternatives that can help farmers reduce their reliance on chemical inputs while maintaining or even improving productivity.

It is the need of the hour that the new agricultural extension system should focus on promoting sustainable farming practices and environmental sustainability. Governments should prioritize initiatives that enhance the cultivation of human capital, improve agricultural management practices, and bolster technical skills among farming communities, with a specific emphasis on post-harvest technologies, with information serving as a catalyst for the promotion of profitable and sustainable agriculture. Today, the focus of agricultural research and development must pivot towards catering to the needs of small and marginal farmers, who constitute a significant majority (86.08%) of landholders. This necessitates a reimagining of agricultural extension services to prioritize sustainable agriculture and the adoption of environmentally friendly technologies, rather than solely focusing on increasing productivity.

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