Review Article

Production Problems of Maize, Biotic & A Biotic Factor and Approaches to Manage the Crop: A review

ABSTRACT

Maize production in the Pakistan faces numerous challenges that hinder large-scale cultivation. These challenges are primarily biotic, includes weeds, nematodes, disease pathogens, and pests (both vertebrate and invertebrate). Furthermore, there are a number of abiotic obstacles, including soil-related problems, unfavorable weather, nutritional deficits, and other agronomic, logistical, and societal limitations. Given the growing global population, many of whom rely on maize as a staple food, as well as its industrial uses, this paper recommends several solutions. Key strategies include adopting proper pest control measures through cultural, chemical, and other methods. For example, pests can be managed by adjusting planting depth expanding the number of extension agents in the area, establishing plant quarantine laboratories, providing soil amendments, and enhancing soil and water management. Cooperatives should be established by farmers to make agricultural inputs more accessible. Furthermore, the government should consider purchasing surplus maize from farmers and offering price incentives to boost the national food reserve, so assisting in resolving the world food issue.

Keywords:Biotic, Abiotic, Pathogen, Maize, food crises

Introduction

After rice and wheat, maize *(Zea mays L.)* is the third most significant cereal crop in the world. It is grown extensively across all agro-ecological zones of Pakistan[1]. Pakistan's maize production in 2024 is estimated to be around 9.847 million tonnes. This figure is based on information from the USDA's International Production Assessment Division (IPAD)[2].The grains can be ground and boiled to make porridge, or they can be prepared by themselves or in combination with pulses. Providing 3434 Kcal/kg of metabolic energy, maize is a significant source of carbohydrates[3]. The grains can be ground and boiled to make porridge, or they can be prepared by themselves or in combination with pulses. Providing 3434 Kcal/kg of metabolic energy, maize is a significant source of carbohydrates [4]. In Pakistan, production is largely by small-scale farmers, with each owning less than two hectares, and relying on traditional farming methods. Limited application of fertilizers, particularly nitrogen, and low soil fertility, pose significant challenges to maize production, particularly in Asia. Additionally, irregular rainfall and periodic droughts reduce maize yields by an average of 15% annually[5]. Despite its widespread use in Pakistan and globally, maize production in Pakistan faces numerous constraints, as discussed below.

Real Challenges in production of Maize

The bottlenecks in this area involve both biotic and abiotic factors. The following are identified as major constraints to maize protection in Pakistan.

Biotic Conditions

Diseases and pests pose a serious threat to this nation's food production. Particularly susceptible to a range of pests and illnesses, such as bacterial, fungal, viral, and nematode infestations, is maize. The severity of these issues varies depending on the agro-ecological zone[6].

Pests

Maize plants are affected by various types of arthropod insects and mollusks that feed on them at all stages of growth—seedling, vegetative, tasseling, and reproductive. These pests frequently cause large crop losses by attacking the roots, stems, leaves, blooms, and grains. Uneven plant stands result from termites and mole crickets destroying seeds in the soil[7]. To manage this, seeds can be treated with chemicals, and Dieldrin sprays can be applied to termite habitats. In the Northern part of Pakistan, significant insect pests that damage maize crops comprise armyworms (Spodoptera exempta and Helicoverpaarmigera), grasshoppers (Zonocerus variegatus), shoot flies (Atherigona spp.), and stem borers (Busseolafusca and Sesamiacalamistis)[8]. Compared to early-season harvests, late-season maize has more severe infestations of stem borer. These pests damage maize in two primary ways: first, through mechanical injury from continuous feeding on the stem, which weakens the plant, making it more likely to wither (dead heart) and lodge (fall over)[9]. Second, stem borers create characteristic perforations on leaves, known as "fenestrations," which reduce the leaves' photosynthetic capacity, leading to poor yields, especially during heavy infestations.Stem borer control can be achieved through cultural practices, such as clearing away and eliminating plant leftovers and infected plants [10]. When used early in the infestation, contact and systemic pesticides are also quite successful in getting rid of larvae before they burrow into the stemsAlthough they very sometimes appear, armyworms (Spodoptera spp. and Helicoverpaarmigera) have the ability to completely destroy crops when they do. For almost three weeks, the gregarious larvae eat together. Wet and dry spells that alternate are frequently associated with outbreaks. By feeding on emerging grains and often chopping them into smaller pieces, these worms drastically lower cereal yields[11]. To manage their impact, deep ploughing immediately after harvest exposes the pupae to direct sunlight, which leads to desiccation and kills the pupae. Chemical control with Uppercott® (Cypermethrin + Dimethoate) provides effective management.Storage pests have a significant impact on maize in addition to field pests. Grain weevils (Sitophilus zea mays) and the smaller grain borer (Rhizoperthadominica) are the two most important storage pests for maize. Both in the field and in storage, infestations might happen [11]. In some cases, pests are confined to the storage area, with infestation either originating from insects already present in the storage facility or from crop contamination during storage transfers between granaries.To control storage pests, it is crucial to maintain strict hygiene in storage areas and ensure the provision of air-tight coverings. It is best to avoid combining fresh and old grains while storing them in order to keep pests away. Furthermore, cereals kept for more than a month for seed or eating should be treated with Actellic or fumigated with Phostoxin to keep pests away [12].

Diseases

Diseases have a major effect on grain crops' potential output. Bacteria, fungus, viruses, nematodes, weeds, and nutritional deficits are the agents that cause these illnesses. Cultural practices, moisture (humidity), temperature (both high and low), and the variety and kind of germplasm utilized all have an impact on the incidence and spread of crop diseases in the ecological zones of Punjab [13].

Pathogen Problems

Abundant foliar diseases including rust, Turcicum blight, Curvularia leaf spot, and Maydis blight were found to be abundant in Pakistan, according to a survey done to determine the prevalence and severity of illnesses in the country. These illnesses, which were brought on by Curvularia species, H. maydis, Helminthosporiumturcicum, and Puccinia species, manifested in varying degrees of severity. Furthermore, Fusarium moniliforme-caused "Pokkhaboeng" disease was found to be especially severe in some regions, with yield losses ranging from 5% to 30% [14]. Smut (Ustilago maydis), downy mildew, maize leaf fleck, and maize streak are some other noteworthy maize diseases found in the Punjab zones. Similar blight, smut, and rust diseases, such as head smut (Sporisoriumreiliana), cover smut (Sphacelothecasorghii), and common rust (Puccinia graminis), have been documented on sorghum [15].There are a number of ways to control these bacterial, viral, and fungal diseases, including using resistant maize varieties, applying systemic fungicides, crop rotation, removing and burning infected plants, eliminating alternate hosts (for rusts), and seed dressing with chemicals like Furadan or Apron Plus. 'Pokkhaboeng' disease can be effectively controlled using some fungicides, such as Rovrus, Delsene, and a mixture of Benomyl and Dithane M45[15].

Nematode Problems

In the Punjab ecological zones, it has been documented that a number of nematode species impact maize roots as well as soil. Pratylenchus species, Aphelenchoides species, Tylenchus species, Helicotylenchus species, Ditylenchus species, and Scutellonema species are among these species. When examined, infected maize plants are found to have shorter roots with profuse tillering and rounded stubs at the terminals. They also frequently topple over at the root level.Chemicals like Furadan 3G and other fumigant nematodes, such as Ethylene Di-bromide (EDB), Dichloropropenes (Telone), and Dichloro chloropropane (Nemagon), can be used to control nematodes [16]. It is important to follow the manufacturer's recommendations to ensure the effectiveness of these treatments.

Weed Problems

Weeds are one of the major challenges in maize production, as improper management can lead to significant grain yield losses ranging from 69% to 92%. Weeds compete with maize crops for essential resources such as nutrients, air, light, and moisture. Striga spp. (witchweed) is a particularly harmful parasitic weed that can severely impact maize yields. Additionally, prevalent and capable of lowering maize yields include Rottboellia spp., Pennisetum purpureum, Cyperus spp., Dactylon spp., and other broadleaf weeds. Several cost-effective control measures can be employed to manage weeds and ensure a satisfactory maize yield[17]. These include crop rotation, using tolerant maize varieties, applying adequate fertilizer, and manually removing weeds before floweringRottboellia spp., Pennisetum purpureum, Cyperus spp., Dactylon spp., and other broad-leaved plants (Compositae) are other perennial weeds that lower maize production in the Punjab[18]. Herbicides such as Stomp, Roundup, Fusilade, and 2,4-D are effective in controlling these weeds.Hand weeding is also a viable option but must be done at the right time and To guarantee a good harvest, this process is performed twice before the crops mature. The majority of cereals have shallow roots, thus hand weeding must be done carefully to prevent mechanical harm to the roots. To keep the roots from being overly exposed to the sun in places that are prone to erosion, it might be required to earth up or remold the ridges [19].

Abiotic Factors

Numerous abiotic elements, such as meteorological circumstances, soil-related problems (edaphic factors), nutrient deficits, and agronomic, logistical, and social concerns, all have an impact on Pakistan's crop production challenges. These factors have a major impact on the region's agriculture yield and growth.

Climatic Problems

The Punjab region, is characterized by several climatic challenges. These include irregular and insufficient rainfall, strong wind speeds, drought, high humidity, and summertime temperatures. Crop failures have frequently resulted from the unexpected commencement, distribution, and overall amount of rainfall in these zones over the previous 10 years [20]. Compared to crops like sorghum, maize requires more water, and its development is significantly impacted by irregular rainfall patterns. Significant grain loss and inadequate pollination are the results of drought, especially during the silking stage [21].Building new irrigation dams and cultivating drought-tolerant or resistant types of sorghum and maize are two ways to combat the problems caused by unpredictable rainfall and drought. Furthermore, as the season goes on, growing maize in tighter rows might aid in lowering soil moisture loss.

Edaphic Factors

The country's Punjab areas are mostly composed of loess (sand deposited by wind), clayey loam, and sandy loam. Essential plant nutrients are severely lacking in these soils, and the organic matter level is usually low (<0.5%). Waterlogging is a serious problem for farmers in certain locations, whereas soil water availability is a big worry in others [22]. Although certain regions record soils with lower pH values, the soils are often alkaline. In some places, soil deterioration is also a result of erosion brought on by both wind and water. Although Punjab's agricultural productivity is hampered by these edaphic issues, they may be addressed with a variety of soil amelioration strategies. Applying organic resources, such as cow dung, chicken manure, farmyard manure, and leaf litter from shelter trees, is one efficient way to improve the physical characteristics of the soil and raise its organic matter content [22]. Shelter belts can be installed in wind-prone locations to prevent wind erosion. Building appropriate drainage systems, embankments, and levees, as well as encouraging plant cover in vulnerable regions, can help reduce flooding and water erosion. Additionally, liming can be used to ameliorate low pH soils so that crops have better access to nutrients [23].

Nutrient Deficiencies

Compared to several other cereals, including wheat, millet, and rice, maize is regarded as a heavy feeder. It needs primary nutrients like potassium, phosphorus, and nitrogen as well as secondary nutrients like sulfur, calcium, boron, iron, chlorine, copper, and so on. in enough amounts [24]. Due to inadequate plant growth, deficiencies in these vital nutrients may result in lower yields. The government should strengthen fertilizer subsidies to incentivize farmers to boost maize output in the area in order to tackle these issues. Establishing cooperative organizations can also aid farmers by facilitating better access to fertilizer and other essential agricultural supplies [25].

Agronomic Factors

Several agronomic practices influence maize production in Pakistan. These practices, if not managed properly, can significantly affect the crop’s growth and yield:

1. Planting Depth: The depth at which maize seeds are planted can impact pest and disease incidence. While shallow planting exposes the seed to termite, rodent, and bird predation and may damage the roots of the seedling, overly deep planting can lead to seed rot. The answer is to sow seeds on ridges or flat surfaces at the suggested depth, which is normally between 2.5 and 4.5 cm. [26].
2. Seedbed Preparation: Poor seedbed preparation results in shallow root systems, weak seed establishment, and vulnerability to lodging and wilting due to insufficient water. Proper seedbed preparation is crucial to guarantee a high yield and proper crop establishment. In the field, deep plowing, harrowing, and ridging assist manage weeds and erosion while facilitating water penetration and exposing pests' eggs and diapason pupae to sunlight for desiccation [27].
3. Removal of Crop Residue: For the next planting season, leftover maize stalks may become a source of disease and insect infestation. Crop wastes can be removed and burned to help shield the crop from these possible dangers. Furthermore, before being used for construction or fence, the stalks of other crops, such guinea corn, should be well dried in the sun [28].
4. Timeliness: Timeliness in crop protection is critical. Even a slight delay in pest management can undermine all efforts and lead to substantial crop loss. For example, stem borers are a major pest of maize. Their larvae dig into the stem after feeding on the immature, unexpanded leaves in the whorl. Targeting the larvae while they are still in the whorl is necessary for effective management. Contact insecticides are useless if treatment is postponed and the larvae have already buried themselves in the stem [29].
5. Storage Pest Control:Certain insect pests begin infesting crops while still in the field and continue to damage the produce during storage. Pests like *Sitophilus spp* (a type of weevil that affects maize and sorghum) can cause significant damage if crops are harvested too late. To minimize yield loss during storage, it is crucial to ensure timely harvesting of crops to prevent these pests from infesting the produce[30].
6. Use of Pesticides: In order to manage agricultural pests and illnesses, pesticides are essential. They come in a variety of forms, including growth regulators, fungicides, bactericides, insecticides, herbicides, and nematicides. For example, compared to mechanical and cultural approaches, herbicides provide a rapid and effective way to manage both annual and perennial weeds. [31]. However, a significant drawback in tropical regions is that herbicides rarely provide long-term control of weeds, especially those that emerge later in the season. Furthermore, problems including soil persistence, plant resistance, and groundwater pollution can result from the inappropriate or excessive application of herbicides. Even when the correct pesticide is applied, its effectiveness may be reduced due to factors like staleness, late application, or incorrect application methods. Another challenge in the northern Pakistan is the high labor costs involved in applying pesticides due to water scarcity. Solutions to these challenges include training more extension workers to assist farmers, implementing water-saving technologies like wells or boreholes, and developing ultra-low volume (ULV) pesticides that can be applied with hand sprayers to reduce water and labor usage[32].

7. Use of Resistant Varieties: In Pakistan, farmers often avoid planting improved resistant maize varieties due to their higher requirements for fertilizers and proper management practices before achieving high yields. To overcome this issue, a concerted effort is needed through effective extension services and educational campaigns to raise awareness and shift farmers' mindset towards adopting resistant varieties that can ensure better pest and disease control, ultimately leading to higher yields[33].

Logistic and Social Problems:

One of the key challenges in maize production in Pakistan is the insufficient extension services available to support the growing number of farmers in the region. These services are crucial for providing farmers with the necessary guidance on best practices for crop management, pest control, and overall agricultural development. Additionally, a significant social issue affecting crop production and protection is the lack of adequate price incentives for farmers, especially during times of natural disasters[34]. Price incentives are essential to ensure that farmers receive fair compensation for their hard work and to encourage continued investment in agriculture. Moreover, it is vital for the government to purchase excess produce and store it in strategic grain reserves. This would help stabilize prices, reduce waste, and provide a safety net for farmers in times of surplus or hardship. By addressing these logistical and social issues, farmers would be better motivated to increase maize production, contributing to the nation's food security[35].

Conclusion

The challenges limiting maize production in Pakistan are primarily driven by unfavorable biotic and abiotic factors. To overcome these obstacles, it is crucial to implement a combination of effective control strategies, including customs, the use of chemicals, and other pertinent techniques. Modifications to agricultural techniques, such as the best planting depth, effective soil and water management, and the use of suitable soil additives, can help address insect problems. Increasing the number of extension agents in the area and setting up plant quarantine labs would also aid in enhancing crop protection initiatives. Additionally, to make it simpler to get necessary agricultural inputs, farmers should be encouraged to establish cooperative groups. It is essential for the government to purchase surplus produce from farmers and provide price incentives, ensuring the stability of food supplies and contributing to national food reserves. These efforts will not only enhance maize production but also help mitigate global food crises by bolstering local food security.

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