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A REVIEW ON ISOPROTURON HERBICIDE GAIN OR DAMAGE REPORTS IN WHEAT (*TRITICUM AESTIVUM* L.)

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ABSTRACT

Among the food crops, wheat is one of the most abundant sources of energy and proteins and its increased production is essential for food security. The undesirable plants (mostly weeds) compete with wheat (*Triticum aestivum* L.) in field for space, solar radiation, nutrients, water and carbon dioxide which might be lead to the hindrances of growth and development of the plant. The rising cost of labour and power, the judicial use of herbicides is the only acceptable way for effective weed management. Herbicides are compounds designed to control the development of undesirable plants that might interfere with the growth of commercial cereal crops. A volume research had been done in last several decades and mixed response of herbicides suggested for the conduction of such experiments at regular interval of time to check their adverse impact on the crop plants in terms of phytomorphology, cytology, biochemical, physiology and histological responses.

Keywords: *Triticum aestivum* L., Unwanted Plants, Herbicides, Isoproturon, Phytodepressive Effects

INTRODUCTION

Higher plants function as one of the essential producers in ecosystems. Also, the plants have important roles in sustaining the integrity of different ecosystems and most importantly living beings were dependant on them for their livelihood and other important activities. Wheat (*Triticum aestivum* L.) is one of the most important food crops of the world and a member of the family Poaceae that includes major cereal crops of the world such as maize, wheat and rice. Among the food crops, wheat is one of the most abundant sources of energy and proteins and its increased production is essential for food security **[1]**. Wheat is characterized by large genome size (approximately 17000 Mb) and 95% of wheat grown today is of hexaploid type, used for the preparation of bread and other baked products. This occupies about 17% of the world's cropped land and contributes 35% of the staple food **[2]**. Also, the largest crop area is devoted to wheat and the quantity produced is more than that of any other crop. Wheat production in India, the world's second largest grower is estimated at record 80980000.0 tons in 2009-10 crop year **[3]**. The production is 12555038.76 times greater than the production in 1949 (6.47.0 tons only) after two years of Indian independence **[3]**. It must credit to the Indian peasants and scientific community to take the challenge and huge production for the more than 1 billion 21 crore Indian population **[3]**.

But, the undesirable plants (mostly weeds), compete with main crop in field for space, solar radiation, nutrients, water and carbon dioxide which might be lead to the hindrances of growth and development of crop and cause reduction in yield of crop. The presence of weeds caused reduction in wheat production up to 30% **[4]**. Weeds not only reduce the crop yield, but also deteriorate quality and market value of the crop. Therefore, to cope up with the rapid increase in population, the scientists need to develop the technology to divert the resources towards the wheat crop than weeds because the conventional methods of weed control are weather dependent, laborious and costly. Also, it seems that wheat is inferior or weak against the weeds growth.

Weed control is the basic requirement and major component of the crop production system **[5]**. Therefore, Chemical weed control is being emphasized in modern agriculture **[6]**. Modern agriculture means the production of wheat without presence of unwanted grasses or weeds above economic threshold. The applied herbicides should not leave any such non-acceptable residues which could affect wheat as well as other crops. The rising cost of labour and power, the judicial use of herbicides is the only acceptable way for effective weed management in future.

Herbicides are compounds designed to control the development of undesirable plants that might interfere with the growth of commercial cereal crops **[7]**. The interaction among herbicides and cereal crops were studied for a long period and suggested that the application of various herbicides in crop field to control weeds caused some abnormal phytomorphological growth, cytogenetical, biochemical and physiological metabolisms in plants **[8, 9, 10]**. Therefore, toxic stress of agrochemicals on higher plants especially in cereal crops is a key challenge in ecosystem health. Unfortunately, in this genomic or molecular biology era, phytomorphological studies were totally ignored (except few) by the researchers and the scientists. Therefore, it is suggested that a range of wheat varieties should be investigated, here and then, in field or green house trials to come across the different side effects of the herbicides or biological stress, if any.

Isoproturon {3-(4-isopropyl phenyl)-1, 1-dimethyl urea} is a phenyl urea-derived systemic herbicide for pre-and post-emergence control of annual and broad leaved weeds or grasses for wheat, barley and rye **[11, 12]**. Isoproturon (IPU) inhibits the electron transport in photosystem II (PS II) by binding to the D1 protein in the thylakoid membrane **[13]**. IPU is one of the herbicides used worldwide because of its relatively high solubility in water and low chemical and biological degradation rate **[14]**. **[15]** suggested that it has been over accumulated in soils as residues and consequently become one of the biological and environmental concerns. Therefore, in relation to the above, some effects of the isoproturon on biological properties of wheat (*Triticum aestivum* L.) were illustrated. The effects indicated were dose dependent, concentration range, and time of application of herbicides on cereal crops and weeds.

The unwanted plant competitions with wheat seedlings usually occurs from the two leaf stage to the onset of reproductive stage leading to the reduction in tillering, ear formation and in stem weight and height reductions giving poor grain filling **[16]**. The herbicides could uptake by plants via roots, foliar entry and subsequently translocated a small component of uptake to other parts of the plant **[17]**. **[18]** reported that a 0.75 kg/ha of IPU applied as Pre-emergence and before first irrigation had a distinct depressing effect on the plant height as well as grain yield. The chemical weed control had been proved to be relatively efficient and economical in controlling the weeds **[19, 20]**. **[21]** reported both Chlortoluron and Isoproturon were readily metabolized to herbicidally inactive products by tolerant cultivars of wheat. Soil application of Isoproturon ($2.5 kgha^{-1}$) caused variable effects surrounding the rhizosphere of wheat seedlings like increase or decrease in number of bacterial and fungal propagules and harmful effects on micro organisms or fertility of soil **[22]**.

The foliar application, absorption and translocation of radiolabelled carbon with isoproturon (^{14}C-IPU) were studied in wheat and indicated the radiolabelled carbon dioxide fixation ($^{14}CO_2$) and translocation (^{14}C) caused phytotoxicity in plants **[23]**. **[24]** demonstrated in preliminary pot experiments that deeper planting of wheat seedlings protected from damage by both pre and post emergence applications of herbicides. The higher rates of isoproturon (5kgha^{-1}) and chlortoluron(2.5kgha^{-1}) were phytotoxic to crop plant (*Triticum aestivum* L.) and decreased the grain yield **[25]**. Weeds grown in wheat fields were strong competitors for nutrients, light, space and moisture and when allowed to compete with the crop upto harvest, depleted 91.2, 19.4 and 77.5 kg of Nitrogen (N), Phosphorus (P) and Potassium (K) per hectare respectively **[26]**. Isoproturon (Graminon, at 5kgha^{-1}), metoxuron (Dosanex, at 4kgha^{-1}), Chlortoluron (Dicuran, at 2.5kgha^{-1}) showed excellent control of weeds, accompanied by significant ($P \leq 0.05$) decrease in plant height (cm), number of spikes, number of tillers, wheat dry weights, biological and grain yields **[26]**. **[27]** suggested that IPU and manual weeding were superior to metoxuron for weed control. Therefore, the selectivity and efficiency of herbicides largely depends on the dose and stage of wheat and weed growth applied **[28]**. The combination of 2, 4-D+IPU reduced dry weed biomass **[29]**. **[30]** reported the non-target effects of sulfonylurea herbicides and suggested that the application of sulfonylurea herbicides to wheat crop (*T. aestivum*) caused yield decrease for sweet cherries (*Prunus avium*) and other crops at the horse heaven hills of Washington State. The herbicide diclofop-methyl applied alone and in combination with IPU significantly increased the grain yield of wheat crop **[31]**. **[32]** reported that isoproturon 50WP (1 kgha^{-1}) showed the lowest weed biomass (433.3kgha^{-1}) than puma super 75 EW (435.0 kg ha^{-1}) and Topik 15 WP (466.7 kg ha^{-1}). The lowest weed biomass in IPU 50 WP treatment indicated the less effect on phytomorphological attributes and showed maximum spike length (8.34 cm), maximum number of spikes m^{-2} (427), maximum number of grains spike^{-1} (38), highest (39.85 g) 1000 grain weight than Puma and Topik. The desired and best performance of IPU 50 WP could be attributed to the best control of grassy broad leaved weeds. The less number of unwanted plants reduced competition of wheat with them and caused increased flow of nutrients towards the grains and ultimately the grain yield was increased. **[33]** reviewed that effects of herbicides on plant communities and suggested their affects on wildlife. The combined application of 2,4-D+IPU reduced dry weed biomass, but increased the straw and grain yield **[34, 35]**. **[36]** showed the response of late sown wheat seeding methods and weed control measures in flood prone areas. **[37]** reported the effects of IPU on photosynthesis in susceptible and resistant biotype of *phalaris minor* and wheat. Also, the crop had capability to degrade IPU by P-450 monooxygenase enzymes. The mixed application of Tralcoxydim+IPU produced higher yield than their alone applications **[38]**. The post-emergence combined application of 2,4-D+IPU showed lower weed dry mass and higher grain yield **[39]**. The foliar application of sulfonylurea herbicides at or shortly before flowering might be caused greater reductions in yield than other growth stages applications **[40]**. The herbicide applications to crop field could contribute to the shift in plant communities. The shift might be from adjacent field to intensively cropped field to native species to more weedy species. Therefore, the adjacent field communities could promote the spread of more weedy species **[41]**.

The selectivity and efficiency of herbicides largely depends on the dose and stage of weed growth **[42]**. The herbicide IPU was metabolized by wheat cell suspension cultures **[43]**. **[44]** showed maximum 1000 grain weight over control treated with 50 WP IPU. The application of different herbicides showed non-significant increase in the plant height **[45]**. There were reports that some of the sulfonylurea herbicides or ALS-inhibiting herbicides cause disruption of synthesis of the branched chain amino acids like leucine, isoleucine and valine which might be lead to accumulate toxic metabolites, disruption of assimilate transport and inhibition of reproduction **[46, 47]**. The mixed application of IPU+Buctril-M produced higher yield than their alone application **[45]**. The combined post emergence application of 2,4-D+IPU producing the highest straw and grain yield **[48, 49]** whereas single application of IPU showed maximum Harvest index percent (31.3%) and highest number of grains spike^{-1} **[48]**. The effective weed control could increase nutrients availability to crop and resulted in higher yield like maximum grain yield (2530 kgha^{-1}) and maximum biological yield (8475 kgha^{-1}). But besides the effective weed control and increased grain yield, the different herbicides attributed to the phytotoxic effects in wheat crop **[50]**. The combined application of 2,4-D+IPU caused reduction in dry weed biomass as a result more space, light, nutrients from soil were available for growth and development of the main crop **[51]**. **[52]** reported the application of sulfonylurea herbicides in field crop causing yield decrease for other crops like *Prunus avium* and suggested that the movement of herbicides from the target plant to other plant as 'herbicide drift'. A stimulatory effect of isoproturon on acid phosphatases, nitrate reductases, peroxidases and an inhibitory effect on alkaline phosphatase were observed **[53]**. Pre-emergence application of IPU alone or with 2,4-D recorded significantly lower grain yield **[54]**. **[55]** reported that isoproturon 50WP had maximum weed kill efficiency (48.3%) as compared to the weedy check and ultimately increased the yield by increased number of spikes m^{-2}, highest (39.85 g) 1000 grain weight and increased flow of nutrients towards grains and suggested that the herbicide IPU 50 WP is the best herbicide at the rate of 1kg ha^{-1} used as post emergence to control weeds and to increase the crop yield. The post emergence application of 2,4-D+IPU reduced dry weed biomass and producing higher grain yield **[56].**

[57] reported that combination of 2,4-D+IPU reduced dry weed biomass and increased grain yield. The wheat growth was sensitive to the IPU exposure in aquatic ecosystem and imposed undesirable side effects on biological properties **[58]**. It was reported that the treatment with 20mgkg^{-1} IPU decreased the root length and shoot elongation to 44% and 32% , while the chlorophyll content decreased by 11% at 2 mgkg^{-1} of IPU as compared to the control **[59]**. **[59]** suggested that IPU induced oxidative stress in wheat and showed negative biological responses like wheat seedling, growth inhibition, chlorophyll content decrease, and change in activities of antioxidant enzymes including Superoxide dismutase (SOD), Peroxidase (POD), Catalase (CAT) and Ascorbic Peroxidase (APX). Growth effects were defined as reduction in phytomorphological parameters in any herbicidal treatment as compared to the control. The wide spread use of herbicides in crop fields suggested reduction in mitotic activity, mitotic inhibition, formation of chromosomal abnormalities, inhibition of DNA synthesis, and formation of irregular and disorganized phragmoplast **[60]**. The cell abnormalities might eventually affect the vigour, yield, fertility and competitive ability of the exposed plant **[61, 62]**. **[63]** reported that herbicides (2,4-D and IPU) had phytodepressive effects on Leaf area (cm^2), internode length (cm), Shoot length (cm), biomass (Fresh/ Dry Weight $g^{-1}plant^{-1}$), seed weight (g $inflorescene^{-1}$), number of seeds $spike^{-1}$ and seed germination percent at a range of concentrations applied (0-1200 ppm) alone and in combination. The percent reduction varies from 38.66% to 49.0% in different parameters studied at different doses of herbicides alone and in combination. The herbicide application showed the potential to affect the growth and development of crop. The indiscriminate use of seeding rates might increase the production cost along with decrease in wheat grain yield and other vegetative or reproductive traits **[64]**. The application of herbicides increased the vegetative growth parameters like plant height (cm), number of spikes m^{-2}, flag leaf area (cm^2), number of grains $spike^{-1}$, straw and grain yield, biochemical composition of crop like crude protein, phosphorus (P), potassium (K) and increased iron (Fe) and zinc (Zn) in wheat grains **[65]**. The application of urea and urease inhibitor N-(n-butyl) thiophosphoric triamide (NBPT) with herbicide significantly increased grain protein content as compared to the alone urea treatment and suggested the increased production and improved quality of wheat grains **[66]**. The application of different herbicides (Topik, Isoproturon, Puma super and Buctril super) on wheat in a randomized complete block design showed higher biological yield in line sowing and higher wheat seed rate **[67]**.

The results obtained by **[63]** were supported by some earlier reports of **[16, 18, 25, 26, 33, 50, 54, 58-62, 64]**. But simultaneously there were some reports suggested the increase in plant height (cm), biomass (Fresh/ Dry Weight), number of seeds $spike^{-1}$, length $spike^{-1}$ and yield growth at different concentrations of herbicides applied alone and in combination **[20, 31, 32, 34, 35, 38, 39, 44, 45, 48, 49, 50, 55, 56, 57, 65, 66, 67]**.

The mixed response of herbicides suggested for the conduction of such experiments at regular interval of time to check their adverse impact on the crop plants in terms of phytomorphology, cytology, biochemical, physiology and histological response. Herbicide application requires permanent investigation for good production, business, high productivity, high value food obtainment, qualitative seed production, new genotype selection, plant growth advancement and total preservation of human environment **[68]**. It could be a long term investment in scientific base, which provided a potential for next century and for better future.

The extent of herbicide effects on non-target plants is largely unknown due to a limited number of field incident reports and controlled experiments to evaluate those potential effects. McCarty **[69]** suggested for development of biomarkers for ecological effects of environmental stresses such as herbicides and pesticides. The development of such biomarkers should be compatible with the new technologies used for chemical and molecular analysis **[70]**. **[71]** suggested that the formulation of biomarkers should be very specific for the herbicidal effects in plants. Molecular biology tools could be used to identify the site and mode of action of different herbicides **[23]**. Microarray based molecular technique might be useful for the detection of gene expression and its response in plants after different herbicide application. The technique could be an advantage for the effective and efficient determination of potential risk, if any, to crops and non target plant species. There were some reports to develop and popularize the organic farming system which could limit or curtail the use of chemical herbicides **[72, 73]**.

CONCLUSION

To increase wheat yield and improve wheat quality had been important goal of research. A great deal of studies had been carried out all over the world but there has been some contradiction between the wheat yield and quality. The demand for food is quite large for its exponential growth of population. Therefore, improving wheat yield has been given priority for wheat breeding and planting for long time. Also, a volume research had been done in last several decades and still many studied were searching for the cultivating methods which could improve the yield and quality.

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