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Integrated weed management in maize-wheat-greengram cropping system under conservation agriculture

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Prologue/Introduction

The maize-wheat-greengram cropping system in India, particularly in the northwestern Indo-Gangetic Plains (IGP), is a popular alternative to rice-based systems. It involves planting maize during the *kharif* season, followed by wheat during the winter (*rabi*) season, and then greengram (mung bean) in the spring. This system is promoted for its potential to address challenges like water table decline, residue burning, and nutritional scarcity. The system is gaining traction as a replacement for rice-wheat cultivation, which has led to deterioration in soil health, soil erosion and environmental issues. Maize is more water-efficient and less labour-intensive than rice, and the inclusion of greengram improves soil health and provides a source of protein. The maize-wheat-greengram system is considered more sustainable than the rice-wheat system, as it promotes soil health, reduces water consumption, and increases nutritional diversity. This system is suitable for conservation agriculture to tap the additional benefit of CA. However, one of the significant challenges associated with CA is the establishment of perennial weeds and weed shifts. By adopting CA with IWM, crop residues burning can be avoided, soil health can be improved by enhancing physical, chemical and biological properties, and more carbon can be sequestrated in the soil profile. This approach also enhances soil moisture retention and helps in restricting the establishment of tough-to-kill weeds and weed shifts, which are challenges in the conservation tillage system with recommended herbicides. Weed management under CA in maize-wheat-greengram cropping system under CA has not been established, therefore, the present study refined integrated different weed management options and herbicide rotations to achieve effective and broad-spectrum weed control within the context of conservation agriculture.

Methodology

A split plot design was employed to evaluate six tillage in main plot [CT-CT-CT, CT-ZT-ZT, ZTGR-ZT-ZTWR, ZT-ZTMR-ZTWR, ZTGR-ZTMR-ZTWR and ZT-ZT-ZT] and in the sub-plot four weed management practices (recommended herbicides, sequential application of herbicides, integrated weed management and weedy check) during 2017 to 2021. The maize variety P4212, wheat GW 273 and greengram samrat/virat were test crops and varieties. Recommended fertilizers maize (120:60:40 kg N, P_2O_5 and K_2O/ha) wheat (120:60:40 kg N, P_2O_5 and K_2O /ha) and greengram (20:60:0 kg N, P_2O_5 and K_2O/ha) were applied as per recommendation at the region. The seeds were sown with normal seed drill in CT plots and happy seeder in ZT plots. The experiment was conducted consecutively from 2017 to 2021.

Results

The adoption of CA, specifically zero-tillage (ZT) with retention of previous crop residues (R) known as ZTR, coupled with integrated weed management (IWM) [atrazine at 1000 g/ha in maize, sulfosulfuron + metsulfuron at 30+2 g/ha in wheat, and pendimethalin at 678 g/ha in greengram combined with hand weeding in the above-mentioned crops] provided several advantages over CT and RH (atrazine 1000 g/ha *fb* 2,4-D 500 g/ha in maize, clodinafop 60 g/ha *fb* 2, 4-D 500 g/ha in wheat and pendimethalin 678 g/ha in greengram). Furthermore, the ZTR with IWM also demonstrated the highest system crop, water, energy productivity and profitability. Along with these benefits, it improved the soil health by sequestrate and stabilizing more carbon in the soil profile. This practice also aided in conserving soil from erosions and reducing GHG emissions. Therefore, CA-based agriculture with IWM, specifically in the maize-wheat-greengram cropping system, offers numerous advantages. By

adopting this approach, farmers can achieve improved soil health, reduced weed growth, increased crop yields, and enhanced profitability while mitigating greenhouse gas emissions and conserving soil resources.

Benefits

a. Productivity gain: The adoption of ZTR-ZTR-ZTR resulted in higher system productivity (SP) in terms of maize equivalent yield (13.16 t/ha), which was 20.3% more than the CT-CT-CT system (10.94 t/ha). The IWM exhibited SP of 16.01 t/ha, which was 36.8% higher SP compared to the use of recommended herbicides (11.70 t/ha).
b. Saving of water, labour and time: The adoption of ZTR-ZTR-ZTR allowed for saving of two irrigations with a 31% reduction in duration, leading to a 25-30% saving in irrigation water. The ZTR-ZTR-ZTR and IWM obtained 77.4 and 36.8% more irrigation water and 25 and 42.9% higher total water productivity, respectively. Additionally, the elimination of soil turning in CA fields saved 7-10 days per season, which could potentially be utilized for growing a third crop in the system.
c. Saving of energy: IWM exhibited a higher net energy of 10.13 x 10^4 MJ/ha, energy productivity of 0.17 kg/MJ, and 42.1% higher energy profitability.
d. Conservation of soil: Protect the soil by >95%
e. Non-point pollution: Minimal, as water does not go out from these plots.
f. Early sowing practice under ZTR protected wheat crop from terminal heat stress and greengram from rains. Resulting in a good crop harvest with quality produce.
g. Efficiency: In the triple ZTR system, WCE improved by 23.6-54.5% over CT system, while IWM demonstrated a 68.7-91.7% higher WCE over the use of RH.
h. Cost effectiveness including benefit cost ratio: The adoption of CA practices resulted in additional net returns of Rs 45,000/ha over CT system, with B: C of 2.77. Likewise, IWM achieved additional net returns of Rs 73000/ha over RH, with a B: C of 3.11.
i. Herbicide residues: The herbicide residues in the seeds/grain, straw/haulm and soil was recorded below the detectable limit (<0.01 µg/g)

Maize-wheat-greengram

CT maize weedy

ZT+R maize weedy

CT maize with topramezone 25.2 g/ha

ZT+R maize with topramezone 25.2 g/ha

ZT+R wheat with weedy check

ZT wheat with weedy check

ZT wheat with mesosulfuron + iodosulfuron 12+2.4 g/ha

ZT+R wheat with sulfosulfuron + metsulfuron 30+2 g/ha

ZT greengram with weedy check

ZT greengram with pendimethalin 678 g/ha

CT greengram with pendimethalin 678 g/ha *fb* HW

ZT + R greengram with pendimethalin 678 g/ha *fb* HW

Upscaling

This technology can be upscaled by the following ways

- Training and demonstration,
- Establishing more custom hiring centres for CA based machineries,
- Converge with state government schemes.

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