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Integrated weed management in conservation agriculture based maize-mustard-greengram cropping system

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Prologue/Introduction

The maize-mustard-greengram cropping system: A sustainable alternative to rice-wheat in India. The maize-mustard-greengram (3M) cropping system is an innovative crop rotation strategy in India that involves sequential cultivation of maize, mustard, and greengram (a cereal, oilseed and pulse crop). This system offers a sustainable and high-yielding alternative to the conventional rice-wheat system, addressing critical issues such as groundwater depletion and residue burning. By integrating greengram, a leguminous crop, the system enhances soil fertility, reduces the dependency on chemical fertilizers, and contributes to improved soil health. The adoption of high-yielding mustard varieties further boosts productivity and diversifies agricultural practices. This diversification lowers the risks associated with mono-cropping, opens up new market opportunities, and improves farm profitability. The 3M system is well-suited for conservation agriculture (CA), enabling farmers to leverage additional benefits such as enhanced resource-use efficiency and long-term soil sustainability. However, a key challenge under CA is the proliferation of perennial weeds and shifts in weed flora. These issues necessitate effective integrated weed management (IWM) strategies. By combining CA with IWM, farmers can avoid residue burning, improve soil's physical, chemical, and biological properties, and enhance carbon sequestration. Moreover, this approach improves soil moisture retention and suppresses the emergence of hard-to-control weeds, a common concern in conservation tillage systems relying solely on herbicides. Despite its potential, weed management in the maize-mustard-greengram system under CA remains underexplored. Therefore, there is an urgent need for interventions to refine integrated weed management practices and herbicide rotations to ensure effective, broad-spectrum weed control within the framework 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-ZTMsR, ZT-ZTMR-ZTMsR, ZTGR-ZTMR-ZTMsR and ZT-ZT-ZT] and in 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, mustard Kranti, and greengram samrat/virat were test crops and varieties. Recommended fertilizers maize (120:60:40 kg N, P_2O_5 and K_2O/ha), mustard (90:60:40 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 seed drill attached with furrow opener in CT plots and happy seeder in ZT plots. The experiment was conducted consecutively from 2017 to 2021.

Results

The adoption of CA [zero-tillage (ZT) with retention of previous crop residues (R), ZTR] coupled with integrated weed management (IWM, atrazine + topramezone 500+25.2 g/ha in maize, pendimethalin 678 g/ha in mustard and pendimethalin 678 g/ha in greengram along with hand weeding in above crops) provided effective weed control, enhanced crop growth and development, increased seed/grain yields, and demonstrated superior economical parameters across all tested crops over conventional agriculture [CT with recommended herbicide (RH) atrazine 1000 g/ha *fb* 2,4-D 500 g/ha in maize, pendimethalin 678 g/ha in mustard and pendimethalin 678 g/ha in greengram]. The ZTR with IWM also achieved the highest system-level crop- water- energy productivity, and profitability. Furthermore, the adoption of CA practices improved soil health, facilitated increased C sequestration and

stabilization in the soil profile, and contributed to soil conservation by reducing erosion and GHG emissions. Therefore, CA based agriculture with IWM be adopted in the maize-mustard-greengram cropping system in permanent ridges and furrows. This approach offers a comprehensive solution that addresses weed management challenges while promoting sustainable agricultural practices.

Benefits

a. Productivity gain: The adoption of ZTR-ZTR-ZTR resulted in a significantly higher system productivity in terms of maize equivalent yield (12.92 t/ha) that was 16.8% higher than CT-CT-CT system (11.06 t/ha). Additionally, the IWM approach exhibited a remarkable 15.60 t/ha of SP that was 36.9% higher than use of RH (11.47 t/ha).
b. Saving of water, labour and time: Adopting ZTR-ZTR-ZTR, two irrigations can be saved with a considerable 30% reduction in irrigation duration, leading to substantial water saving of 30-35%. The CA and IWM achieved 67.6 and 39.6% more irrigation water and 25.3 and 39.5% total water productivity, respectively. Furthermore, since CA fields do not require soil turning, 6-8 days/season can be saved, offering the possibility of growing an additional crop within the system.
c. Saving of energy: Integrated weed management demonstrated higher net energy of 8.2 x 10^4 MJ/ha, energy productivity of 0.09 kg/MJ and an impressive 48.3% increase in energy profitability compared to the use of RH.
d. Conservation of soil: Protect the soil by >95%
e. Non-point pollution: Minimal, as water hardly goes out from these plots.
f. Early sowing practice under ZTR can save 7-10 days each season, which can be potentially utilized for growing an additional crop in the system.
g. Efficiency: In the triple ZTR system, WCE improved by 41.4-65.2% over CT system, while IWM demonstrated a substantial 63.9-96.3% higher WCE over the use of RH.
h. Cost effectiveness including benefit cost ratio: The adoption of CA practices provided additional net returns of Rs 39,000/ha over CT system, with a B: C of 3.00. Likewise, IWM achieved additional net returns of Rs 73000/ha over the use of RH with a B: C of 3.36.
i. Herbicide residues: The seeds/grain, straw/haulm and soil was recorded herbicides residues below detectable limit (<0.01 µg/g) except atrazine.

Maize-mustard-greengram ridges and furrows

ZT+R maize with atrazine + topramezone (500 + 25.2 g/ha)

ZT+R maize with atrazine 1000 g/ha *fb* 2,4-D 500 g/ha

CT maize with atrazine + topramezone (500 + 25.2 g/ha) *fb* HW

CT maize with atrazine 1000 g/ha *fb* 2,4-D 500 g/ha

ZT+R maize with weedy

ZT+R maize with atrazine + topramezone (500 + 25.2 g/ha)

CT mustard with pendimethalin 678 g/ha

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

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

CT mustard with oxyfluorfen 150 g/ha

CT mustard with pendimethalin 678 g/ha

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

ZT+R mustard with oxyfluorfen 150 g/ha

ZT+R mustard with pendimethalin 678 g/ha

CT greengram with pendimethalin 678 g/ha

ZT+R 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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