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Assessing the Efficacy of Different Herbicides for Controlling Weeds in Rabi Onion (*Allium cepa* L) at Saharsa District of Bihar, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

An effort was undertaken to determine the best weed management techniques for controlling weeds in onions that are both practically and financially viable for farmers. Due to weed competition, onions, which are shallow-rooted, slow-growing crops, can experience significant

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output loss. Their non-branching nature and short, upright leaves make them less competitive with weeds. Additionally, they allow for multiple flushes of weeds because to their lengthy growing season, frequent irrigation, and fertilizer application. During the Rabi season in 2017 and 2018, the experiment was carried out in the farmers' fields of Saharsa district, Bihar, using the "On Farm Trial" mode for two years. Technology option-III, which yielded the maximum net return of up to Rs 275420 q/ha, was the best treatment in terms of net return. The benefit-to-cost ratio differed greatly between the therapies. Technology option III had the highest benefit cost ratio (2.92), which was comparable to Technology option II (2.66) statistically.

Keywords: Weed management; irrigation; fertilizer; rabi season.

1. INTRODUCTION

Because of its distinctive flavor, the onion (*Allium cepa* L.) is commonly referred to as the "Queen of the Kitchen." India is the world's second largest producer of onions, following China. In India, it is grown on 1.28 million hectares with an average yield of 23.26 million tonnes and a poor productivity of 18.1 tonnes per hectare [1]. It is mostly utilized in gastronomy and culinary applications, as well as to avoid coronary heart disease and other ailments [2]. Onions are slow-growing, shallow-rooted crops that can experience significant output loss due to weed competition. Their small, straight leaves and non-branching nature make them ineffective weed competitors. Additionally, they allow for multiple flushes of weeds because to their lengthy growing season, frequent irrigation, and fertilizer application [3,4]. This kind of growth behavior makes it difficult for onion crops to compete with weeds; yield loss in onions caused by weed infestation has been reported to be between 40 and 80% Channapagoudar et al., [5] and Urraiya and Jha, [6]. According to Singh et al. [7], unchecked weed development can also lower bulb yields in onion fields by 40–80%, depending on the type, severity, and duration of weed competition. Different herbicides have been employed singly or in combination to eradicate weeds during the past few decades, however due to their limited range of weed control, their efficacy varies [8,9]. A severe labor shortage makes weed control extremely challenging during crucial times, leading to a significant yield disparity. The traditional weed-control techniques (weeding and hoeing) are time-consuming, costly, and ineffective. Therefore, an effort was made to identify the best weed management techniques for controlling weeds in onions that would be both practically successful and financially viable for farmers.

2. MATERIALS AND METHODS

During the Rabi season in 2017 and 2018, the experiment was carried out in the farmers' fields of Saharsa district, Bihar, using the "On Farm Trial" mode for two years. For this experiment, the cultivar Nasik-53 was planted during the final week of October. Three replications of a Randomized Block Design (RBD) were employed. The land was plowed by a tractor and then harrowed due to its clayey loam nature. The plants were spaced 15 centimeters apart by 10 centimeters within a 3 x 3 meter plot. Just before transplantation, NPK was sprayed at the appropriate amounts, and four weeks after transplanting, half of the nitrogen was applied. The crop was harvested in the last week of April. Table 1 provides details on technology assessment/refinement, farming situation, area of intervention, and technology options.

Table 1. Shows the technology options evaluated in Rabi 2017 and 2018

Problem Area	**Important Cause**	**Production System**	**Micro Farming Situation**
Low productivity of Onion	High infestation of Weeds	Rice- Onion	Irrigated medium land with clay to sandy clay loam soil
Intervention Plan			
Farmers' practice-I	Hand Weeding (HW) at 30 DAS		
Technology option-II	Pendimethalin @ 3ml/l as pre-emergence followed by Oxyfluorfen @ 1ml/l within 30-32 days		
Technology option-III	Pendimethalin @ 3ml/l as pre-emergence followed by Imazathapyr @ 1.2ml/l as post-emergence at 45 DAT		

3. RESULTS AND DISCUSSION

3.1 Growth and Yield Parameters

In terms of all growth and yield characteristics as well as bulb yield, the two weed management treatments outperformed the farmers plot (Table 2). Technology option-III displayed the highest growth attributes (plant height, neck thickness) and yield attributes (polar and equatorial diameter and bulb weight) as well as bulb yield. In contrast, Technology option II ranked second in each of these categories. Conversely, under the farmers plot (without chemical pesticides and hand weeding), the lowest growth and yield parameters as well as bulb output were reported. It may be because chemical weeding, specifically in Technology option-III, reduces weed crop competition during the crop growth period. This preserves soil fertility by preventing weeds from removing plant nutrients, which in turn has a positive impact on growth parameters and yield attributes. These results are in close agreement with studies conducted on other crops by Bhartia et al. [10], Kalhapure et al. [11], Gandolkar et al. [12], and Kumar et al. [13]. Higher crop growth and bulb weight in Technology option-III indicated that the crop was growing in a more favorable environment. Less crop weed completion at an earlier stage of crop growth was the cause of this rise in crop growth.

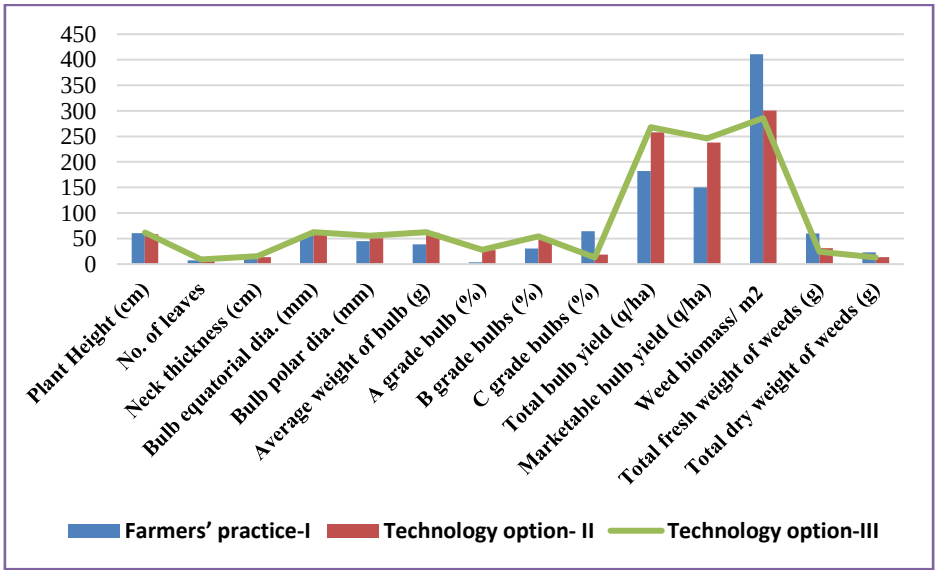

Fig. 1. Effect of herbicide application on growth and yield characters of onion Var N-53

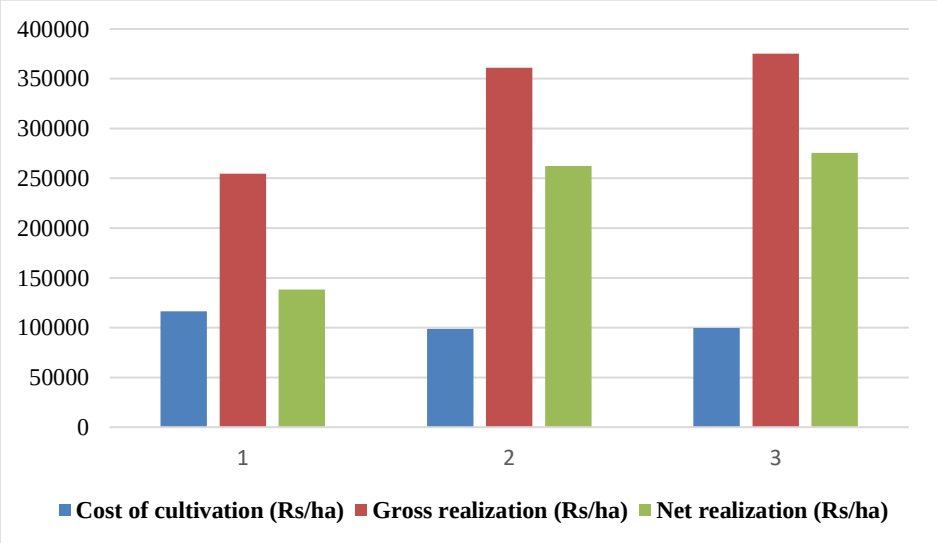

Fig. 2. Effect of herbicide application on economics of onion Var N-53

Table 2. Effect of herbicide application on growth and yield characters of onion Var N-53

Treatment	Plant Height (cm)	No. of Leaves	Neck Thickness (cm)	Bulb Equatorial Dia. (mm)	Bulb Polar Dia. (mm)	Average Weight of Bulb (g)	A grade Bulb (%)	B grade Bulbs (%)	C grade Bulbs (%)	Total Bulb Yield (q/ha)	Marketable Bulb Yield (q/ha)
Farmers' practice-I	60.4	7.3	12.4	55.6	45.0	38.4	3.60	30.5	64.2	182	150
Technology option- II	58.8	9.1	13.6	56.7	50.9	61.2	27.4	47.9	18.7	258	238
Technology option-III	61.8	9.1	15.3	62.5	55.5	62.5	28.0	54.3	13.1	268	246
SEm ±	**0.88**	**0.76**	**0.55**	**0.71**	**0.83**	**0.58**	**1.18**	**0.59**	**0.41**	**0.77**	**1.06**
CD at 5%	**2.08**	**1.80**	**1.30**	**1.67**	**1.97**	**1.36**	**2.80**	**1.38**	**0.98**	**1.83**	**2.50**
CV (%)	**1.03**	**6.33**	**2.82**	**0.86**	**1.17**	**0.75**	**2.46**	**0.94**	**0.91**	**0.23**	**0.20**

Table 3. Effect of herbicide application on weed parameters and Economics of onion Var N-53

Treatment	Weed Biomass/ m^2	Total Fresh Weight of Weeds (g)	Total Dry Weight of Weeds (g)	Cost of Cultivation (Rs/ha)	Gross Realization (Rs/ha)	Net Realization	B:C Ratio
Farmers' practice-I	411.0	60.1	22.8	116390	254800	138410	1.18
Technology option-II	300.4	31.0	13.8	98808	361200	262392	2.66
Technology option-III	285.7	24.5	12.7	99780	375200	275420	2.92
SEm ±	**0.69**	**0.63**	**0.35**	**-**	**-**	**-**	**-**
CD at 5%	**1.62**	**1.50**	**0.83**	**-**	**-**	**-**	**-**
CV (%)	**0.08**	**1.16**	**1.51**	**-**	**-**	**-**	**-**

3.2 Crop Yield

The highest bulb yield (268 q/ha) was obtained in Technology option-III, i.e. Pendimethalin @ 3ml/l as pre-emergence followed by Imazathapyr @ 1.2ml/l as post-emergence at 45 days after transplanting, followed by Technology option-II, i.e. Pendimethalin @ 3ml/l as pre-emergence followed by Oxyfluorfen @ 1ml/l within 30-32 days. The farmer's plots produced the lowest bulb output (182 q/ha). Combinations of herbicide-treated plots produced higher results due to efficient weed control, which allowed the crop to use available resources efficiently to create a high yield. Weed competition may be the cause of the farmers plot's lowest production (182 q/ha). Consequently, the crop receives less light, moisture, and nutrients, which causes the weeded plot to yield less. This validates Verma and Singh's [14] results about onions. A weed-free plot helped the onion bulb crop grow and mature more quickly by reducing weed competition to a greater extent. This led to higher values of all yield-attributing features being obtained. Regarding onion yield, the results are quite similar to those published by other researchers Warade et al. [15] and Saraf [16].

3.3 Dry Weight of Weeds

The distinct herbicide treatments were shown to have a substantial impact on the total dry weight of weeds (Table 3). Farmers' Practice I yielded the greatest dry weight of 22.8g. However, Technology option-III has the lowest dry weight (12.7). According to Patel et al. [17], the dry weight of weeds may result from both enhanced nutrient intake and ongoing weed population growth. The variations in the range of weeds present and the range of control offered by each herbicide may be the cause of the variation in the weed population between the several treatments. These findings concurred with those of Khokhar et al. [18] and Ghaffoor [19].

3.4 Effect on Economic Returns

Although in terms of net return, Technology option-III was the best treatment; it yielded the maximum net return of up to Rs 275420 q/ha. The benefit-to-cost ratio differed greatly between the therapies. Technology option III had the highest benefit cost ratio (2.92), which was comparable to Technology option II (2.66) statistically. However, the farmer's plot yielded the lowest benefit cost ratio (1.18) per hectare. Technology option-III produced the highest benefit-cost ratio because the weed-free plot helped the onion bulb crop grow and develop more quickly by reducing weed competition to a larger extent. This led to higher values of all yield-attributing features. The results of Nandal and Singh [20] and Pugalendhi et al. [21], who examined the economic returns parameters in INM in onion crop under varied climatic conditions, support the findings regarding gain of highest monetary returns and cost-benefit ratio with integrated weed management practices.

4. CONCLUSION

Based on a two-year period of data, it can be concluded that the best option for chemical weed control in onion crops to achieve desired yields is to apply Pendimethalin @ 3 ml/l as pre-emergence followed by Imazathapyr @ 1.2 ml/l as post-emergence at 45 DAT. This combination significantly reduced the weed count and weed dry matter in the onion crop and gave significantly higher plant height, bulb yield, net return, and B:C ratio when compared to other treatments tested.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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