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Integrated nutrient and weed management on weed dynamics, growth, grain yield and economics of buckwheat (*Fagopyrum esculentum* L.) production

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Abstract

A field experiment was conducted during winter season of 2019-20 at Uttar Banga Krishi Viswavidyalaya to study the effect of integrated nutrient and weed management on weed dynamics, growth, grain yield and economics of buckwheat production. Results indicated that all the growth and yield attributing characters were significantly influenced due to effect of integrated nutrient and weed management. Highest grain yield was recorded with 50% RDF + Vermicompost @ 1.5 t ha⁻¹ × Rice straw mulch @ 5 t ha⁻¹ applied at 2 DAS (16.5 q ha⁻¹) which was statistically similar with 100% RDF × Rice straw mulch @ 5 t ha⁻¹ applied at 2 DAS (15.8 q ha⁻¹) and 50% RDF + Vermicompost @ 1.5 t ha⁻¹ × Oxyfluorfen 23.5% EC @ 0.2 kg ha⁻¹ at 2 DAS + One hoeing at 40 DAS (15.6 q ha⁻¹). The lowest was recorded with control (7.2 q ha⁻¹). Weed biomass was decreased and weed control efficiency was increased in all the nutrient management treatment combined with Oxyfluorfen 23.5% EC @ 0.2 kg ha⁻¹ at 2 DAS + One hoeing at 40 DAS followed by Rice straw mulch @ 5 t ha⁻¹ applied at 2 DAS and Oxyfluorfen 23.5% EC @ 0.2 kg ha⁻¹ at 2 DAS. Higher B:C ratio observed with 100% RDF combined with all the weed management treatment (3.87-3.52) followed by 50% RDF + Vermicompost @ 1.5 t ha⁻¹ (2.43-2.62) and Vermicompost @ 3 t ha⁻¹ (1.41-1.64) combined with all the weed management treatment except control (1.84).

Keywords: Weed dynamics, growth, grain yield, economics, buckwheat

Introduction

Common buckwheat (*Fagopyrum esculentum* Moench) has been a crop of secondary importance in many countries and presently cultivated throughout the world (Campbell, 1997)^[6] and now-a-days, the crop is become the potential or future crop (Yadav *et al.*, 2017)^[24] in terms of adaptation to climatic variables (Baniya, 2001)^[3]. The crop is known as pseudo-cereal as its grains belong to cereals because of their similar use and chemical composition. Grains consume as staple food by tribal community in North-Eastern hilly tract of India. The crop is cultivated for dual uses, leafy vegetable as well as grains in some parts of India (Paul and Nandi, 2020)^[16]. Nutrient management is a very important tool for proper growth and development of crops. Application of chemical fertilizers may increase production but at the same time its lead to soil pollution. Organic manures applied in a sequence improve the use efficiency of inorganic fertilizers. The combined use of organic manures and inorganic fertilizers provides a sustainable soil nutrient balance, enhances soil aggregation, and increases moisture retention capacity and soil fertility (Tadesse *et al.*, 2013)^[22]. Organic manure on the other side, provide a good substrate for the growth of the microorganism and maintain a favourable nutrient supply environment to the crop. Efficiency of nutrient supply and economics of crops under organic and inorganic sources of nutrient management has immense importance for higher profitability. Among various organic manures, vermicompost are commonly used organic manures in plant nutrient management. Manure application has also been reported to increase the N and exchangeable cation levels in the soil (Boateng *et al.*, 2006)^[4]. The application of vermicompost had favourable effects on soil pH, microbial population and soil enzyme activities (Maneswarippa *et al.*, 1999)^[15].

Weeds are major biotic factor in the crop production. Weeds compete for resources viz. water,

nutrient, space and light, resulting in significant yield losses (Ghosh *et al.*, 2020; Kaur *et al.*, 2018) [8, 10]. The heavy infestations of composite weeds pose decline production and quality of produce. Of the various factors responsible for low productivity, weed management during critical period of weed competition is of great implication. The dose and source of nutrients, especially nitrogen, will influence the weed community structure (Ghosh *et al.*, 2018) [8]. The replacement of inorganic fertilizers with organic sources may help in reduction of weed dynamics. Chemical weed control is a preferred practice (Kumar *et al.*, 2016; Kundu *et al.*, 2020) [12, 13] due to scarce and high labour cost as well as lesser feasibility of manual weeding (Singh *et al.*, 2015). However, sole dependency on herbicides raises serious concerns about environmental pollution, herbicide residues in the food chain, development of herbicide-resistant weeds and deterioration of soil biological health (Boily *et al.*, 2013; Van Der Meulen, and Chauhan, 2017) [5, 10]. The integration of non-chemical weed management approaches with herbicides not only increases weed control efficiency, but also overcome problems associated with over-reliance on herbicides alone (Ghosh *et al.*, 2017) [8]. At present, some herbicide molecules having its very high potency at lower doses to kill weeds have been developed. These molecules may be more effective to control various weed species as well as relatively safer for environmental pollution point of view. Mulching also helps in retention of soil moisture contents and suppresses weeds growth without herbicide application (Pervaiz *et al.* 2009) [17]. Organic mulches help to moderate soil temperature, provide efficient control of weeds, decrease rate of evaporation and add nutrients and humus in the soil (Kluepfel, 2010) [11]. Application of straw mulch show positive effects on crop production, biological yield and water utilization efficiency of field crops (Wang *et al.* 2009) [23]. The present investigation was undertaken to study the effect of integrated nutrient and weed management on weed dynamics, growth, grain yield and economics of buckwheat production.

Materials and Methods

A field experiment was carried out during winter (*rabi*) seasons of 2019-20 at the instructional farm of Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal to study the effect of integrated nutrient and weed management on weed dynamics, growth, grain yield and economics of buckwheat production. The farm is situated at 26°19'86" N latitude and 89°23'53" E longitude at an elevation of 43 meter above mean sea level. The physico-chemical properties of experimental soil was sandy loam in texture with pH 5.49, medium in organic carbon (0.68%), medium in available nitrogen (176.5 kg/ha), medium in Available phosphorus (13.6 kg/ha) and low in available potassium (69.4 kg/ha). The experiment was laid out in randomized block design having ten treatment combinations having 3 nutrient management and 3 weed management treatment and one additional control (weedy) [viz: T₁: control T₂: 100% RDF × Rice straw mulch @ 5 t ha⁻¹ applied at 2 DAS, T₃: 100% RDF × Oxyfluorfen 23.5% EC @ 0.2 kg ha⁻¹ at 2 DAS, T₄: 100% RDF × Oxyfluorfen 23.5% EC @ 0.2 kg ha⁻¹ at 2 DAS + One hoeing at 40 DAS, T₅: 50% RDF + Vermicompost @ 1.5 t ha⁻¹ × Rice straw mulch @ 5 t ha⁻¹ applied at 2 DAS, T₆: 50% RDF + Vermicompost @ 1.5 t ha⁻¹ × Oxyfluorfen 23.5% EC @ 0.2 kg ha⁻¹ at 2 DAS, T₇: 50% RDF + Vermicompost @ 1.5 t ha⁻¹ × Oxyfluorfen 23.5% EC @ 0.2 kg ha⁻¹ at 2 DAS + One hoeing at 40 DAS, T₈: Vermicompost @ 3.0 t ha⁻¹ × Rice straw mulch @ 5 t ha⁻¹ applied at 2 DAS, T₉: Vermicompost @ 3.0 t ha⁻¹ × Oxyfluorfen 23.5% EC @ 0.2 kg ha⁻¹ at 2 DAS and T₁₀:

Vermicompost @ 3.0 t ha⁻¹ × Oxyfluorfen 23.5% EC @ 0.2 kg ha⁻¹ at 2 DAS + One hoeing at 40 DAS] replicated thrice. The soil was prepared by tractor drawn cultivator followed by rotavator. The whole experimental field was divided into thirty small plots having the size 4 m × 4 m following the layout plan. Vermicompost and fertilizers were broadcasted on the respective plots prior to layout preparation. First 2/3 of N, full dose of P and K were applied as basal and remaining 1/3 N was top dressed at 30 DAS. Fertilizers were applied through urea, single super phosphate and muriate of potash. Rice straw mulch was applied one day after sowing, as per treatment taken under study. Pre-emergence application of Oxyfluorfen 23.5% EC was done at one day after sowing and post-emergence application done at 40 days after sowing (DAS). The buckwheat variety 'Himpriya' was taken in the present study. The seed was sown on 04th December, 2020 maintaining 30 cm × 10 cm plant geometry. Two irrigation was given during the crop growth period. The crop was matured in last week of February and harvested on 28th February, 2021. Harvesting was done manually when all leaves and inflorescences turned yellow colour and grains moisture content around 20%.

Herbicide application

The amount of herbicide required for each plot was calculated on the basis of the following formula.

$$Q = \frac{10 \text{ RA}}{P}$$

Where, Q = Quantity of herbicide required in gm or ml.

R = Rate of application in kg ha⁻¹

A = Area in m²

P = Percentage of active ingredient in commercial formulation.

The quantity of Oxyfluorfen 23.5% EC for the respective plots was determined according to the active ingredient present in the commercial products. The calculated amount of herbicide was dissolved in required amount of water (500 l ha⁻¹) and sprayed uniformly in the plot as per treatment through knapsack sprayer fitted with flood jet nozzle at 2 DAS.

Dry weight of weeds (g m⁻²)

Composite weed samples were collected at 20, 40, and 60 DAS by placing 1.0 m × 1.0 m (1 m²) quadrats randomly in each plot. Weeds were cleaned by washing in water, then kept in sunlight for few hours and then kept in a hot air oven at 62 °C for 72 hours or more till constant weight was obtained. Finally, their dry weight was recorded with an electronic balance.

Weed control efficiency (WCE)

Misra and Tosh replaced weed density in Mani formula by dry weight to calculate weed control efficiency. To determine WCE of individual treatment, the following formula was used and expressed in percentage.

$$WCE = \frac{WDMC - WDMT}{WDMC} \times 100$$

Where,

WCE = Weed control efficiency

WDMC = Weed dry weight (m⁻²) in control plot

WDMT = Weed dry weight (m⁻²) in treated plot

Growth and yield attributes: Samples of five plants were taken

from each two inner rows of each plots and taken immediately to the laboratory to determine: Plants height (cm), Dry matter accumulation (g plant^{-1}), Leaf area index (LAI), Number of branches plant^{-1} (primary and secondary), Number of seeds plant^{-1} , Number of seed clusters plant^{-1} , Number of seeds cluster $^{-1}$, and Test weight (1000 grain weight).

Grain yield and harvest index: Net plot (6.3 sq.m) was harvested from the inner six rows for yield estimation. After threshing, grain was sun dried and weight for each plot was taken separately and then converted into q ha^{-1} . Harvest index was determined by the following formula as suggested by Donald.

$$\text{Harvest index} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

Economics

Net returns of individual treatment were worked out by subtracting the cost of cultivation from the gross returns. Benefit-cost ratio was obtained from the following formula:

$$\text{Benefit-cost ratio (B:C)} = \frac{\text{Gross return}}{\text{Cost of cultivation}}$$

Statistical analysis: Data were analysed using ANOVA in randomized block design and the treatment variations were tested at 5% level of significance by 'F' test.

Results and Discussion

Weed dynamics

Dry matter accumulation (g m^{-2})

The results indicated that the weed dry matter accumulation and weed control index was significant at 20, 40 and 60 DAS (Fig. 1). At 20 DAS, weed dry matter accumulation was decreased in all the treatment combination except control. At 40 DAS, weed

dry matter accumulation was decreased in all the nutrient management treatment combined with Rice straw mulch @ 5 t ha^{-1} applied at 2 DAS followed by Oxyfluorfen 23.5% EC @ 0.2 kg ha^{-1} at 2 DAS + One Hoeing at 40 DAS and Oxyfluorfen 23.5% EC @ 0.2 kg ha^{-1} at 2 DAS except control. Whereas, at 60 DAS, weed dry matter accumulation was decreased in all the nutrient management treatment combined with Oxyfluorfen 23.5% EC @ 0.2 kg ha^{-1} at 2 DAS + One hoeing at 40 DAS followed by Rice straw mulch @ 5 t ha^{-1} applied at 2 DAS and Oxyfluorfen 23.5% EC @ 0.2 kg ha^{-1} at 2 DAS except control. Pre emergence application of herbicide in combination with hand hoeing effectively reduced the weed count up to 60 DAS (Rana *et al.* 2004, Ghosh *et al.* 2020) [20, 8].

Weed control efficiency

At 20 DAS, weed control efficiency (WCE) was increased in all the treatment combination except control (Fig. 2). At 40 DAS, WCE was increased in all the nutrient management treatment combined with Rice straw mulch @ 5 t ha^{-1} applied at 2 DAS. WCE was decreased in all the nutrient management treatment combined with Oxyfluorfen 23.5% EC @ 0.2 kg ha^{-1} at 2 DAS + One Hoeing at 40 DAS and Oxyfluorfen 23.5% EC @ 0.2 kg ha^{-1} at 2 DAS whereas, at 60 DAS, it was increased in all the nutrient management treatment combined with Oxyfluorfen 23.5% EC @ 0.2 kg ha^{-1} at 2 DAS + One Hoeing at 40 DAS followed by Rice straw mulch @ 5 t ha^{-1} applied at 2 DAS and Oxyfluorfen 23.5% EC @ 0.2 kg ha^{-1} at 2 DAS except control. The bio-efficacy of herbicides killed the weeds composite and increased WCE. Pre emergence application of herbicide in combination with mulch or hand hoeing effectively reduced the weed biomass at 40 DAS (Rana *et al.* 2004, Priya *et al.* 2017, Ghosh *et al.* 2020) [20, 18, 8]. Pre emergence application of oxyflurfen killed weed seedlings through contact action and membrane disruption, since light is required for herbicidal activity, diphenyl ether phytotoxicity is related to the process of photosynthesis and inhibition of both electron transport and ATP synthesis (Janaki *et al.* 2013, Priya *et al.* 2017) [9, 18].

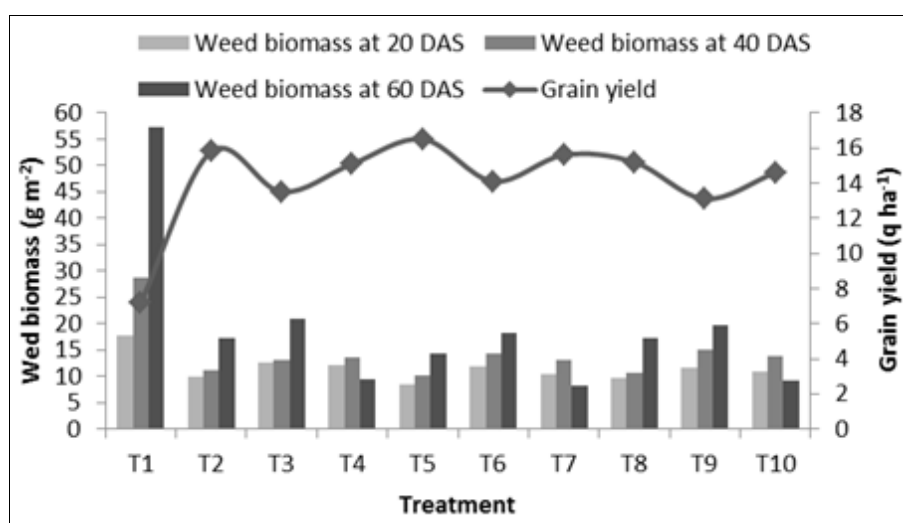


Fig 1: Effects of integrated nutrient and weed management on weed biomass and grain yield of buckwheat

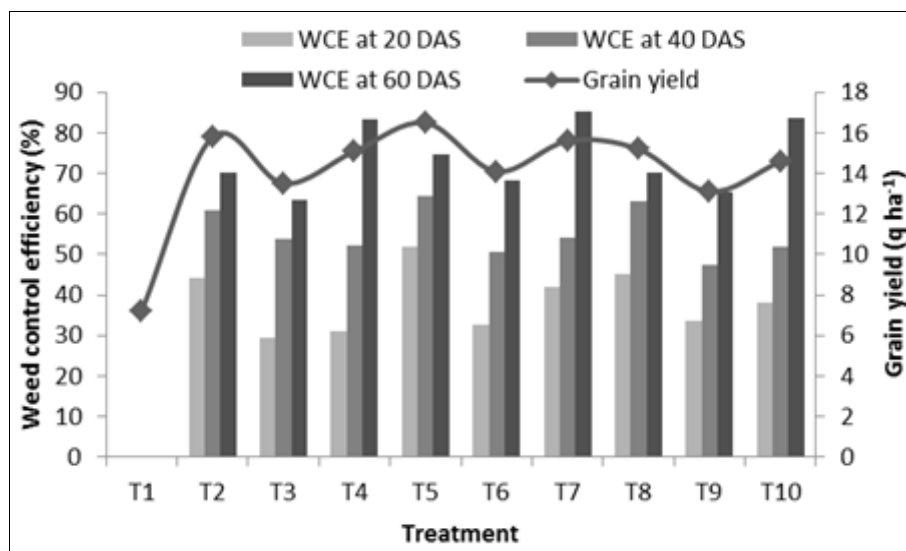


Fig 2: Effects of integrated nutrient and weed management on weed control efficiency (WCE) and grain yield of buckwheat

Growth parameters

Data pertaining to the plant height of buckwheat were significantly influenced due to integrated nutrient and weed management practices (Table 1 & Fig. 3). The tallest plant was recorded with 50% RDF + Vermicompost @ 1.5 t ha⁻¹ × Rice straw mulch @ 5 t ha⁻¹ applied at 2 DAS (104.7 cm) and lowest was recorded with control (67.0 cm). Significantly highest dry matter accumulation was recorded with 50% RDF + Vermicompost @ 1.5 t ha⁻¹ × Rice straw mulch @ 5 t ha⁻¹ applied at 2 DAS (543.7 g m⁻²) followed by 100% RDF (Recommended dose of fertilizer @ 40:20:20 kg ha⁻¹ N: P₂O₅: K₂O) × Rice straw mulch @ 5 t ha⁻¹ applied at 2 DAS (524.8 g m⁻²). At 20 DAS, significantly highest leaf area index was recorded with 50% RDF + Vermicompost @ 1.5 t ha⁻¹ × Oxyfluorfen 23.5% EC @ 0.2 kg ha⁻¹ at 2 DAS + One hoeing at 40 DAS (0.054). Whereas, at 40 and 60 DAS, significantly highest leaf area index was recorded with 50% RDF + Vermicompost @ 1.5 t ha⁻¹ × Rice straw mulch @ 5 t ha⁻¹ applied at 2 DAS (2.26 and 2.81). Integrated nutrient management treatment might have increased interception, absorption and utilization of radiant energy which in turn increased photosynthesis and finally leaf area index at successive stage. Similar results were also reported by Dadarwal *et al.* (2009)^[7] and Mahapatra *et al.* (2018)^[14].

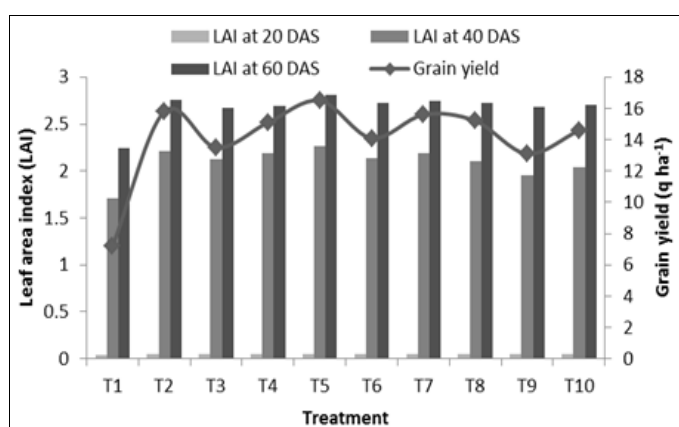


Fig. 3 Effects of integrated nutrient and weed management on leaf area index (LAI) and grain yield of buckwheat

Yield attributes

Data pertaining to yield attributes viz., average number of

primary and secondary branches plant⁻¹, seed yield plant⁻¹, number of seed cluster plant⁻¹, number of seed cluster⁻¹ and test weight were significantly influenced due to integrated nutrient and weed management practices (Fig. 4). The results revealed that number of primary branches plant⁻¹ was found non-significant both at 40 DAS and at harvest. Whereas, at 40 DAS, number of secondary branches plant⁻¹ observed non-significant and at harvest it was significant. All the treatment was at par in number of secondary branches plant⁻¹ except control. It was observed that seed yield plant⁻¹ was significant. No. of seed cluster plant⁻¹ and No. of seed cluster⁻¹ was significant. More No. of seed cluster plant⁻¹ recorded with T₅ whereas, More No. of seed cluster⁻¹ recorded with T₇. The T₅ recorded highest test weight. The consequence of integrated sources of nutrients might be attributed to the favourable nutritional status of soil resulting into better nutrients absorption and plant growth. The present findings were in close agreement with the results obtained by Dadarwal *et al.* (2009)^[7] and Mahapatra *et al.* (2018)^[14]. Pre emergence application of herbicide in combination with hand hoeing effectively increased yield attributes. The finding was conformity with (Ghosh *et al.* 2020)^[8]. Application of mulch also suppressed the growth of weeds and increased yield characteristics.

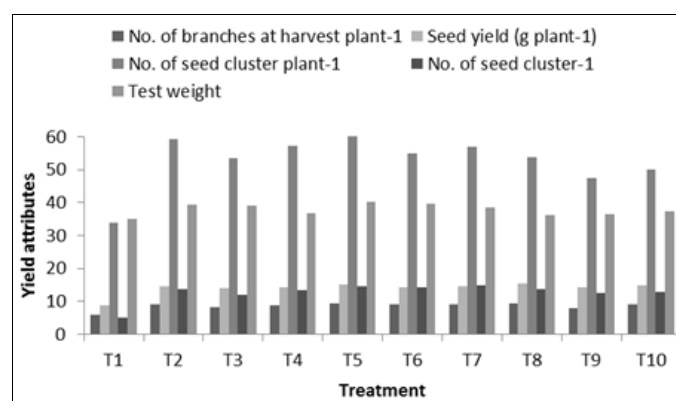


Fig. 4 Effects of integrated nutrient and weed management on yield attributes of buckwheat

Grain yield and harvest index

Data pertaining to yields were significantly influenced due to integrated nutrient management practices (Table 1). The highest grain yield was recorded with 50% RDF + Vermicompost @ 1.5

t ha⁻¹ × Rice straw mulch @ 5 t ha⁻¹ applied at 2 DAS (16.5 q ha⁻¹) which was statistically at par with 100% RDF × Rice straw mulch @ 5 t ha⁻¹ applied at 2 DAS (15.8 q ha⁻¹) and 50% RDF + Vermicompost @ 1.5 t ha⁻¹ × Oxyfluorfen 23.5% EC @ 0.2 kg ha⁻¹ at 2 DAS + One hoeing at 40 DAS (15.6 q ha⁻¹). It was apparent from the result that pre-emergence application of herbicides combined with one hoeing significantly reduced the weed dry matter and recorded higher grain yield of buckwheat. Pre-emergence application of oxyfluorfen 23.5% EC @ 250 g/ha⁻¹ recorded higher pod yield of groundnut (Priya *et al.* 2017)^[18]. Application of mulch restricted the sunlight to reach into the soil and suppressed the growth of weeds, especially broad leaved weeds upto early 60 days' growth.

Significantly highest harvest index was recorded with 50% RDF + Vermicompost @ 1.5 t ha⁻¹ × Rice straw mulch @ 5 t ha⁻¹ applied at 2 DAS (35.8) followed by 100% RDF × Rice straw mulch @ 5 t ha⁻¹ applied at 2 DAS (35.2) and 50% RDF + Vermicompost @ 1.5 t ha⁻¹ × Oxyfluorfen 23.5% EC @ 0.2 kg ha⁻¹ at 2 DAS + One hoeing at 40 DAS (35.4). Highest harvest index was observed in maize with rice straw mulch and minimum in weedy check (Asif *et al.* 2020)^[2].

Economics

The highest net return (₹ 000 × ha⁻¹) was observed with 100% RDF × Rice straw mulch @ 5 t ha⁻¹ applied at 2 DAS (62.6) followed by 100% RDF × Oxyfluorfen 23.5% EC @ 0.2 kg ha⁻¹ at 2 DAS + One Hoeing at 40 DAS (61.6) and 50% RDF + Vermicompost @ 1.5 t ha⁻¹ × Rice straw mulch @ 5 t ha⁻¹ applied at 2 DAS (60.0) (Table 1). The lowest was of control (24.2). It was showed that the higher B:C observed with 100% RDF combined with all the weed management treatment (3.87-3.52) followed by 50% RDF + Vermicompost @ 1.5 t ha⁻¹ (2.43-2.62) and Vermicompost @ 3 t ha⁻¹ (1.41-1.64) in combination with all the weed management treatment except control (1.84). Higher net return and B:C recorded with 100% RDF and 50% RDF combined with vermicompost. Similar results were also reported by Dadarwal *et al.* (2009)^[7] and Mahapatra *et al.* (2018)^[14]. The maximum B:C ratio was obtained with sole inorganic fertilizer as a nutrient source and the integration of herbicide with hoeing for weed management in maize (Ghosh *et al.* 2020)^[8]. It was reported that economics of groundnut cultivation showed that new formulation of oxyfluorfen at 250 g ha⁻¹ recorded the higher net return and B:C ratio (Priya *et al.* 2017)^[18].

Table 1: Effects of integrated nutrient and weed management on growth parameters, grain yield, harvest index and economics of buckwheat

Treatment	Plant height (cm)	Dry matter accumulation (g m ⁻²)	Grain yield (q ha ⁻¹)	Harvest index (%)	Net return (₹ 000 × ha ⁻¹)	B:C
T ₁	67.0	337.2	7.2	23.6	24.2	1.84
T ₂	100.3	524.8	15.8	35.2	62.6	3.40
T ₃	94.7	487.5	13.5	33.2	54.1	3.52
T ₄	95.0	508.3	15.1	34.7	61.6	3.87
T ₅	104.7	543.7	16.5	35.8	60.0	2.43
T ₆	101.0	511.4	14.1	33.9	50.9	2.35
T ₇	100.7	500.1	15.6	35.4	58.2	2.62
T ₈	102.0	515.3	15.2	37.3	47.1	1.52
T ₉	104.0	485.2	13.1	35.4	39.4	1.41
T ₁₀	103.3	498.3	14.6	36.4	46.7	1.64
LSD (p=0.05)	8.40	18.23	1.29	4.93	6.41	0.31

Conclusion

On the basis of experimental findings, it could be concluded that application of 100% RDF/ 50% RDF + Vermicompost @ 1.5 t ha⁻¹ combined with Rice straw mulch @ 5 t ha⁻¹ at 2 DAS / Oxyfluorfen 23.5% EC @ 0.2 kg ha⁻¹ at 2 DAS + One hoeing at 40 DAS gave higher weed control efficiency, grain yield and B:C ratio. Therefore, the treatment combination 50% RDF + Vermicompost @ 1.5 t ha⁻¹ combined with Oxyfluorfen 23.5% EC @ 0.2 kg ha⁻¹ at 2 DAS + One hoeing at 40 DAS might be recommended to the farmers for production of buckwheat in Eastern Sub-Himalayan India.

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