N, P and K uptake by crop and weed as influenced by nutrient levels and weed management in mustard

ABSTRACT

A field experiment was conducted in *Rabi* season of 2018-19 and 2019-20 at Research farm of Bihar Agricultural College, Sabour to assess the impact of nutrient and weed management on N, P and K uptake by crop and weed in mustard. This experiment with 3 nutrient levels (N_1-soil test-based recommended dose of fertilizer (RDF), N_2-100 % RDF, N_3-125 % RDF) in main plot; 8 weed management (W_1-Weedy, W_2-Hand weeding (HW), W_3-pendimethalin, W_4-pendimethalin followed by (*fb)* quizalofop, W_5-pendimethalin *fb* clodinafop, W_6-oxyflourfen, W_7-oxyflourfen *fb* quizalofop, W_8-oxyflourfen *fb* clodinafop) in sub plots, laid in split plot design. Results indicated that in 2018-19, N, P and K uptake by mustard was found maximum under 125% RDF. Hand weeding exhibited highest N, P and K uptake by crop over weedy. Among herbicides, maximum N, P and K uptake by crop was noted with pendimethalin 30 EC 1.0 kg a.i. ha^{-1} PE *fb* quizalofop 5 EC 60 g a.i. ha^{-1} PoE. In 2019-20, hand weeding at 25 and 50 DAS along with 125% RDF exhibited highest N, P and K uptake by crop. Among herbicides, application of pendimethalin 30 EC 1.0 kg a.i. ha^{-1} PE *fb* quizalofop 5 EC 60 g a.i. ha^{-1} PoE along with 125% RDF exhibited highest N, P and K uptake by the crop. In both the years 2018-19 and 2019-20, hand weeding at 25 and 50 DAS along with 125% RDF exhibited N uptake by weeds, zero value being lower than weedy. In 2018-19, application of pendimethalin 30 EC 1.0 kg a.i. ha^{-1} PE *fb* quizalofop 5 EC 60 g a.i. ha^{-1} PoE along with 125% RDF exhibited the lowest N and K uptake by weeds. Among nutrient levels, application of 125% RDF exhibited the lowest P uptake by weeds, however, among herbicides; application of pendimethalin 30 EC 1.0 kg a.i. ha^{-1} PE *fb* quizalofop 5 EC 60 g a.i. ha^{-1} PoE registered the lowest P uptake by weeds. In 2019-20, application of pendimethalin 30 EC 1.0 kg a.i. ha^{-1} PE *fb* quizalofop 5 EC 60 g a.i. ha^{-1} PoE along with 125% RDF exhibited the lowest N, P and K uptake by weeds. Thus it was concluded that pendimethalin 1.0 kg a.i. ha^{-1} PE *fb* quizalofop 60 g a.i. ha^{-1} PoE along with 125% RDF (100:50:50:25:6.25 kg NPKSZn ha^{-1}) enhanced N, P and K uptake by crop though hand weeding at 25 and 50 DAS along with 125% RDF (100:50:50:25:6.25 kg NPKSZn ha^{-1}) exhibited significant improvement in nutrient uptake by crop.

Key words: Mustard, Nutrient levels, N P K uptake, Soil test based fertilizer, Weed control

INTRODUCTION

Indian mustard (*Brassica juncea* L.) is an important winter (*rabi*) season oilseed potential crop owing to its vast adaptable and suited to exploit residual amount of soil moisture (Mukherjee, 2010). Due to a gap between supply and demand, around 60 % of the edible oils consumed in the country are met through imports. Edible oil produced from mustard does not meet the requirement of the growing population of the country. Mustard productivity status at present scenario requires to be improved. As this crop is grown in any type of soil with inappropriate management practice, weed flora is one of major causes of low productivity. Weeds being harmful or poisonous, injurious are constant source of trouble for successful growth and development of mustard. Weed competition in mustard is extremely serious in early stage; because growth of the crop remains very slow during early winter season during the first 4-5 weeks after sowing stage. During later stage it rapidly flourishes and become suppressing effect on the weeds (O-Donovan *et al*., 2007). The critical period of crop-weed competition in mustard is 15-35 days and weeds cause alarming decline in production of the crop ranging from 15-30 % to a failure in crop yield (Shekhawat *et al*., 2012) depending on nature and duration of crop-weed competition.

Weeds compete with crops for moisture, nutrients, light, space and create interference with normal growth of mustard (Upadhyay *et al*., 2012). Weeds create severe hurdle for mustard

cultivation, reduced the soil moisture and fertility, act as alternate host for insect & diseases and pose a serious threat to the next crop (Chopra and Saini 2007). At present, at 25-30 DAS stage, one hand weeding is enough to control the weeds in early stage, but in case of scarcity of labour availability and huge wages, hand weeding become costlier and difficult (Bijarnia *et al*., 2012). Therefore, it is essential to find effective pre-, post- emergence herbicides and their combinations which may control early flush of weeds. The combinations of herbicide are more effective tools in tackling this menace, due to weed infestation and thereby, nutrient uptake by crop and weeds than a single herbicide approach (Upadhyay *et al*. 2013).

Among agronomic options available for augmentation of crop production, fertilizer/nutrient scheduling is the most important production element and is considered as one of the most critical inputs in crop production profitability. In view of such problem issues, the present investigation was carried out to develop the suitable fertilizer and weed control technology for nutrient (N, P and K) uptake in mustard.

MATERIALS AND METHODS

A field experiment was carried out in *rabi* season of 2018-19 and 2019-20 at Research Farm of Bihar Agricultural College, Sabour, Bhagalpur situated at latitude 25°15' 40" N and longitude 87°2' 42" E with an altitude of 37.46 meters above mean sea level with the objective to find out the influence of nutrient levels and weed management strategies on N, P and K uptake by crop and weed in mustard. The soil of experiment was sandy loam, neutral pH 7.2, low organic carbon 0.48 %, low available N 123.47 kg ha^{-1}, medium available P 26.19 kg ha^{-1} and medium K 168.51 kg ha^{-1}. The experiment was laid out in split plot design with three nutrient levels *viz*., N_1-soil test-based recommended dose of fertilizer (RDF) (100:40:40:20:6.25 kg ha^{-1} N P K S Zn), N_2-100 % RDF (80:40:40:20:5 kg ha^{-1} N P K S Zn), N_3-125 % RDF (100:50:50:25:6.25 kg ha^{-1} N P K S Zn) in main plot and eight weed management practices *viz*. W_1-Weedy, W_2-Hand weeding (HW) at 25 & 50 DAS, W_3-pendimethalin 30 EC @ 1.0 kg a.i. ha^{-1} as pre emergence (PE), W_4-pendimethalin 30 EC @ 1.0 kg a.i. ha^{-1} PE *fb* quizalofop 5 EC @ 60 g a.i. ha^{-1} as post emergence (PoE), W_5-pendimethalin 30 EC @ 1.0 kg a.i. ha^{-1} PE *fb* clodinafop 15 WP @ 60 g a.i. ha^{-1} PoE, W_6-oxyflourfen 23.5 EC @ 150 g a.i. ha^{-1} PE, W_7-oxyflourfen 23.5 EC @ 150 g a.i. ha^{-1} PE *fb* quizalofop 5 EC @ 60 g a.i. ha^{-1} PoE, W_8-oxyflourfen 23.5 EC @ 150 g a.i. ha^{-1} PE *fb* clodinafop 15 WP @ 60 g a.i. ha^{-1} PoE in sub plots, replicated thrice. During crop season, minimum and maximum temperature ranged between 3.9°C to 20.4°C and 22.0°C to 32.7°C, respectively. While mean relative humidity was in the range of 64.9%, respectively. Total rainfall received during crop growing season was 93.80 mm. The average sunshine hour was 5.74 hrs. From the meteorological data, it was clear that the weather parameter such as temperature, relative humidity and sun shine hours were more or less congenial for growth and development of mustard.

To conduct the experiment, field preparation practices *viz*., ploughing, harrowing and leveling were done as per recommended standard technique. Mustard seeds were sown in furrows having seed rate 5 kg ha^{-1} on 22th November, 2018 and on 20th November, 2019 and crop was harvested on 11th March, 2019 and 08th March, 2020, respectively. N, P, K, Zn and S doses was applied *viz*., soil test based, 100 and 125 % RDF as basal and remaining N was top dressed into split doses. Source of Zn and S was zinc sulphate monohydrate 33%. Sources of K, P and N were muriate of potash (60% K_2O), di-ammonium phosphate (46% P_2O_5, 18% N) and di-ammonium phosphate/urea (46% N), respectively. Weed management strategies i.e., twice hand weeding at 25 and 50 DAS, pre-emergence alone and/ or with post emergence herbicide application were done treatment wise. Herbicides were applied through a manually operated knapsack sprayer with flat fan nozzle using 500 liter water ha^{-1}.

Two quadrates of 25 x 25 cm were placed randomly in each plot and weeds within the quadrates were removed and after drying in hot air oven (70 ± 10^{0}C for 72 hrs), weed dry weight was recorded. Plant samples of seed and straw of mustard crop collected at harvesting were dried in hot air oven. Plant and weed samples were analyzed for uptake of nitrogen, phosphorus and potash as per standard laboratory procedures (Jackson,1973). The uptake of nutrients was

computed by multiplying the concentration of nutrient with grain yield, straw yield of mustard and dry matter of weed. The experimental data were analyzed statistically by applying analysis of variance (ANOVA) technique prescribed for the design to test the significance of treatment difference by F test and conclusions were drawn at 5% probability level (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

N, P and K uptake by mustard crop

Among nutrient levels, N uptake by mustard crop was found to have a maximum value of 65.07 and 65.74 kg ha^{-1} in 2018-19 and 2019-20, respectively under 125% RDF (100: 50: 50: 25: 6.25 kg N P K S Zn ha^{-1}) which was significantly (P<0.05) superior over rest of the nutrient treatments. P uptake by mustard crop was significantly (P<0.05) highest value of 10.72 and 10.85 kg ha^{-1} in 2018-19 and 2019-20, respectively under 125% RDF (100: 50: 50: 25: 6.25 kg N P K S Zn ha^{-1}) which was at par with soil test-based fertilizer application in 2018-19 only and was significantly superior over 100% RDF. Application of 125% RDF registered significantly highest K uptake of 32.03 and 32.74 kg ha^{-1} in 2018-19 and 2019-20, respectively which was at par with soil test-based fertilizer application in 2018-19 only and was significantly superior over 100% RDF (Table 1).

Table 1: Effect of nutrient and weed management on N, P and K uptake (kg ha^{-1}) by mustard during 2018-19

Treatments	N uptake		P uptake		K uptake	
	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20
Nutrient levels						
N_1- Soil test-based RDF	59.23	60.12	9.94	10.03	28.88	29.64
N_2-100%RDF (80:40:40:20:5 kg NPKSZn ha^{-1})	55.53	56.02	9.27	9.36	27.31	27.80
N_3-125% RDF (100:50:50:25:6.25 kg NPKS Zn ha^{-1})	65.07	65.74	10.72	10.85	32.03	32.74
SEm±	1.46	1.02	0.26	0.18	0.90	0.76
CD (P=0.05)	5.71	4.02	1.01	0.71	3.54	2.97
Weed management						
W_1- Weedy	36.42	34.45	5.85	5.61	17.20	16.74
W_2- Two hand weeding at 25 and 50 DAS	70.57	72.83	11.77	11.98	34.90	35.26
W_3- Pendimethalin 30 EC 1.0 kg a.i. ha^{-1} PE	58.34	60.49	9.64	10.22	28.25	30.21
W_4- Pendimethalin 30 EC 1.0 kg a.i. ha^{-1} PE *fb* Quizalofop 5 EC @ 60 g a.i. ha^{-1} PoE	65.69	65.92	10.97	11.02	32.76	32.91
W_5- Pendimethalin 30 EC 1.0 kg a.i. ha^{-1} PE *fb* Clodinafop 15 WP @ 60 g a.i. ha^{-1} PoE	64.74	65.41	10.93	10.86	31.91	32.75
W_6- Oxyflourfen 23.5 EC @ 150 g a.i. ha^{-1} PE	56.87	58.00	9.37	9.55	27.57	27.80
W_7- Oxyflourfen 23.5 EC @ 150 g a.i. ha^{-1} PE *fb* Quizalofop 5 EC @ 60 g a.i. ha^{-1} PoE	63.15	64.50	10.61	10.75	31.98	32.44
W_8-Oxyflourfen 23.5 EC @ 150 g a.i. ha^{-1} PE *fb* Clodinafop 15 WP @ 60 g a.i. ha^{-1} PoE	63.77	63.40	10.66	10.66	30.70	32.37
SEm±	1.73	1.39	0.30	0.28	0.86	0.89
CD (P=0.05)	4.95	3.96	0.87	0.79	2.46	2.55
Interaction (WxN)						
SEm±	3.00	2.41	0.53	0.48	1.50	1.55
CD (P=0.05)	NS	7.62	NS	1.50	NS	5.00

Different weed management treatments showed significant influence on uptake of nitrogen, phosphorus and potassium by mustard crop at harvest. Significantly the lowest uptake of nitrogen, phosphorus and potassium by the crop were noted under weedy plot. The highest uptake of N, P and K was recorded under hand weeding treatment. This might be due to better development of

crop resulting from lesser crop-weed competition as uptake of a particular nutrient was the function of nutrient content and it's dry matter accumulation. Further, the higher content and higher crop yield under these treatments boosted the nutrient uptake. Similar results were reported by Patel (2000) in pigeonpea and Chauhan (2000) in chickpea.

Among weed management practices, hand weeding at 25 and 50 DAS exhibited significantly ($P<0.05$) highest N, P and K uptake (70.57, 11.77 and 34.90 kg ha^{-1} in 2018-19, respectively) and (72.83, 11.98 and 35.26 kg ha^{-1} in 2019-20, respectively) by mustard crop which was found superior over weedy plot. Among herbicides, maximum N, P and K uptake (65.69, 10.97 and 32.76 kg ha^{-1} in 2018-19, respectively) and (65.92, 11.02 and 32.91 kg ha^{-1} in 2019-20, respectively) by mustard crop was recorded with W_4 (Pendimethalin 30 EC @ 1.0 kg a.i. ha^{-1} PE *fb* Quizalofop 5 EC @ 60 g a.i. ha^{-1} PoE) which was at par with rest of the herbicide treatments except W_3 and W_6.

The higher nutrients uptake was due to the suppression of weed growth that might have been the driving force behind higher dry matter and nutrient uptake in mustard under these treatments. Such higher uptake might be attributed to higher seed yield under better weed management treatments. The results of higher nutrients uptake by crop confirmed the findings of Chander *et al*. (2013) and Mukherjee (2014) in mustard. Minimum nutrient uptake in mustard was noticed in weedy check that might be attributed to least seed yield (Singh *et al*., 2015).

In 2019-20, hand weeding at 25 and 50 DAS with 125 % RDF (N_3W_2) exhibited significantly highest N uptake (82.77 kg ha^{-1}) by mustard crop which was significantly superior over all other herbicide treatments including weedy plot (N_3W_1). Application of Pendimethalin 1.0 kg a.i. ha^{-1} PE Quizalofop 60 g a.i. ha^{-1} PoE (N_3W_4) registered significantly highest N uptake (72.48 kg ha^{-1}) by mustard crop which was found at par with rest of the treatments except N_3W_3, N_3W_6 and N_3W_1 (Table 2).

The superiority of the treatments might be ascribed to the fact that these treatments controlled and suppressed weed growth and provided weed free environment to the crop for long time to utilize available/applied nutrients under reduced crop-weed competition (Kour *et al*., 2014).

Table 2: Interaction effect of nutrient and weed management on N uptake (kg ha^{-1}) by crop at harvest during 2019-20

Weed management / Nutrient Levels	W_1- Weedy	W_2- Two HW at 25 & 50 DAS	W_3- Pendi methalin 1.0 kg a.i. ha^{-1}	W_4-Pendi methalin 1.0 kg a.i. ha^{-1} PE + Quizalofop 60 g a.i. ha^{-1} PoE	W_5- Pendi methalin 1.0 kg a.i. ha^{-1} PE + Clodinafop 60 a.i. ha^{-1} PoE	W_6- Oxyflourfen 150 g a.i. ha^{-1}	W_7- Oxyflourfen 150 g a.i. ha^{-1} + Quizalofop 60 g a.i. ha^{-1} PoE	W_8- Oxyflourfen 150 g a.i. ha^{-1} + Clodinafop 60 g a.i. ha^{-1} PoE
N_1-Soil test RDF 100:40:40:20:6.25 kg NPKSZn ha^{-1}	35.98	71.87	60.94	63.90	63.09	59.60	63.44	62.09
N_2-100% RDF 80:40:40:20:5 kg NPKSZn ha^{-1}	29.06	63.87	58.71	61.40	60.99	57.53	60.35	56.26
N_3-125% RDF 100:50:50:25:6.25 kg NPKSZn ha^{-1}	38.31	82.77	61.82	72.48	72.16	56.88	69.70	71.84
SEm (±)	2.41				2.47			
CD (P=0.05)	7.62 (Levels of W at same level of N)				7.83 (Levels of N at same level of W)			

In 2019-20, hand weeding at 25 and 50 DAS with 125 % RDF (N_3W_2) registered significantly highest P uptake (13.36 kg ha^{-1}) by mustard crop which was found at par with N_3W_1 and N_3W_8 and was significantly superior over rest of the treatments including weedy plot (N_3W_1). Application of Pendimethalin 1.0 kg a.i. ha^{-1} PE Quizalofop 60 g a.i. ha^{-1} PoE (N_3W_4) exhibited significantly highest

P uptake (12.22 kg ha^{-1}) by mustard crop which was found at par with rest of the treatments except N_3W_3, N_3W_6 and N_3W_1 (Table 3).

Table 3: Interaction effect of nutrient and weed management on P uptake (kg ha^{-1}) by crop at harvest during 2019-20

Weed management / Nutrient Levels	W_1-Weedy	W_2-Two HW at 25 & 50 DAS	W_3-Pendi methalin 1.0 kg a.i. ha^{-1}	W_4-Pendi methalin 1.0 kg a.i. ha^{-1} PE + Quizalofop 60 g a.i. ha^{-1} PoE	W_5- Pendi methalin 1.0 kg a.i. ha^{-1} PE + Clodinafop 60 a.i. ha^{-1} PoE	W_6-Oxyflourfen 150 g a.i. ha^{-1}	W_7-Oxyflourfen 150 g a.i. ha^{-1} + Quizalofop 60 g a.i.ha^{-1} PoE	W_8-Oxyflourfen 150 g a.i. ha^{-1} + Clodinafop 60 g a.i. ha^{-1} PoE
N_1-Soil test RDF 100:40:40:20:6.25 kg NPKSZn ha^{-1}	5.91	12.04	10.13	10.62	10.48	9.99	10.59	10.48
N_2-100% RDF 80:40:40:20:5 kg NPKSZn ha^{-1}	4.71	10.55	9.94	10.22	9.97	9.86	10.16	9.48
N_3-125% RDF 100:50:50:25:6.25 kg NPKSZn ha^{-1}	6.21	13.36	10.59	12.22	12.12	8.80	11.49	12.02
SEm (±)	0.48				0.48			
CD (WxN)	1.50 (Levels of W at same level of N)				1.51 (Levels of N at same level of W)			

Table 4: Interaction effect of nutrient and weed management on K uptake (kg ha^{-1}) by crop at harvest during 2019-20

Weed management / Nutrient Levels	W_1-Weedy	W_2-Two HW at 25 & 50 DAS	W_3-Pendi methalin 1.0 kg a.i. ha^{-1}	W_4-Pendi methalin 1.0 kg a.i. ha^{-1} PE + Quizalofop 60 g a.i. ha^{-1} PoE	W_5- Pendi methalin 1.0 kg a.i. ha^{-1} PE + Clodinafop 60 a.i. ha^{-1} PoE	W_6-Oxyflourfen 150 g a.i. ha^{-1}	W_7-Oxyflourfen 150 g a.i. ha^{-1} + Quizalofop 60 g a.i.ha^{-1} PoE	W_8-Oxyflourfen 150 g a.i. ha^{-1} + Clodinafop 60 g a.i. ha^{-1} PoE
N_1-Soil test RDF 100:40:40:20:6.25 kg NPKSZn ha^{-1}	17.56	34.92	30.04	32.15	30.90	29.35	31.75	30.46
N_2-100% RDF 80:40:40:20:5 kg NPKSZn ha^{-1}	13.71	30.24	29.30	31.10	29.56	28.06	30.57	29.85
N_3-125% RDF 100:50:50:25:6.25 kg NPKSZn ha^{-1}	18.96	40.60	31.30	35.46	37.80	25.98	35.01	36.78
SEm (±)	1.55				1.63			
CD (P=0.05)	5.00 (Levels of W at same level of N)				5.28 (Levels of N at same level of W)			

The increased availability of these nutrients in root zone coupled with increased metabolic activity at cellular level might increase nutrient uptake and their accumulation in vegetative plant parts. Increased uptake of N, P and K seems to be due to the fact that uptake of nutrient is a product of biomass accumulated by particular part and its nutrient content. Thus, positive impact of nutrient application on both these aspects ultimately led to higher accumulation of nutrients. These results are in line with the finding of Chaurasia *et al*. (2009) and Singh and Pal (2011).

In 2019-20, hand weeding at 25 and 50 DAS with 125 % RDF (N_3W_2) exhibited significantly highest K uptake (40.60 kg ha^{-1}) by mustard crop which was found at par with N_3W_5, N_3W_8 and N_3W_4 and was significantly superior over rest of the treatments including weedy plot (N_3W_1) (Table 4).

Application of Pendimethalin 1.0 kg a.i. ha^{-1} PE Quizalofop 60 g a.i. ha^{-1} PoE (N_3W_4) recorded significantly highest K uptake (37.80 kg ha^{-1}) by mustard crop which was found at par with N_3W_8, N_3W_4 and N_3W_7. Application of 125% RDF with hand weeding twice registered more N, P and K uptake by the crop during both the years. These observations are in agreement with finding of Shekhawat *et al*. (2012) and Chaudhry *et al*. (2011).

N, P and K uptake by weeds

In 2018-19, hand weeding at 25 and 50 DAS with 125% RDF (N_3W_2) exhibited N uptake by weeds of zero value which was significantly lower than weedy plot with 125% RDF (N_3W_1). Application of Pendimethalin 1.0 kg a.i. ha^{-1} PE *fb* Quizalofop 60 g a.i. ha^{-1} PoE with 125% RDF (N_3W_4) exhibited the lowest N uptake (4.76 kg ha^{-1}) by weeds which was found at par with N_3W_5 and N_3W_7 and was significantly inferior to rest of the treatments (Table 6).

Table 5 : Effect of nutrient and weed management on N, P and K uptake (kg ha^{-1}) by weeds at 60 DAS during 2018-19

Treatments	N uptake		P uptake		K uptake	
	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20
Nutrient levels						
N_1- Soil test-based RDF	9.36	11.68	2.51	3.30	8.51	11.69
N_2-100%RDF (80:40:40:20:5 kg NPKSZn ha^{-1})	11.22	9.36	3.22	2.57	10.88	8.92
N_3-125% RDF (100:50:50:25:6.25 kg NPKS Zn ha^{-1})	7.15	7.09	1.99	2.05	6.35	6.03
SEm±	0.59	0.78	0.18	0.05	0.41	0.61
CD (P=0.05)	2.31	3.06	0.71	0.21	1.63	2.41
Weed management						
W_1- Weedy	21.48	22.37	6.47	6.47	18.00	19.12
W_2- Two hand weeding at 25 and 50 DAS	0.00	0.00	0.00	0.00	0.00	0.00
W_3- Pendimethalin 30 EC 1.0 kg a.i. ha^{-1} PE	8.84	9.27	2.50	3.08	8.94	9.54
W_4- Pendimethalin 30 EC 1.0 kg a.i. ha^{-1} PE *fb* Quizalofop 5 EC @ 60 g a.i. ha^{-1} PoE	7.19	7.08	2.07	2.07	7.44	6.83
W_5- Pendimethalin 30 EC 1.0 kg a.i. ha^{-1} PE *fb* Clodinafop 15 WP @ 60 g a.i. ha^{-1} PoE	7.28	7.17	2.24	2.24	7.78	8.00
W_6- Oxyflourfen 23.5 EC @ 150 g a.i. ha^{-1} PE	11.97	11.97	2.54	2.54	9.36	10.13
W_7- Oxyflourfen 23.5 EC @ 150 g a.i. ha^{-1} PE *fb* Quizalofop 5 EC @ 60 g a.i. ha^{-1} PoE	7.97	7.97	2.42	2.42	8.48	8.81
W_8-Oxyflourfen 23.5 EC @ 150 g a.i. ha^{-1} PE *fb* Clodinafop 15 WP @ 60 g a.i. ha^{-1} PoE	9.22	9.16	2.32	2.32	8.65	8.63
SEm±	0.37	0.25	0.21	0.06	0.54	0.47
CD (P=0.05)	1.06	0.71	0.61	0.18	1.55	1.35
Interaction (WxN)						
SEm±	0.64	0.43	0.37	0.11	0.94	0.82
CD (P=0.05)	1.83	1.64	NS	0.36	2.69	2.83

In 2018-19, 125 % RDF (N_3) exhibited the lowest N, P and K uptake (7.15, 1.99 and 6.35 kg ha^{-1}) by weeds which was found at par with N_1 in case of P uptake only and was significantly inferior over 100 % RDF (N_2). In 2019-20, 125 % RDF (N_3) exhibited the lowest N, P and K uptake (7.09, 2.05 and 6.03 kg ha^{-1}) by weeds which was found at par with N_2 in case of N uptake only and was significantly inferior over soil test-based RDF (N_1).

In 2018-19, among herbicides, application of Pendimethalin 1.0 kg a.i. ha^{-1} PE *fb* Quizalofop 60 g a.i. ha^{-1} PoE (W_4) registered significantly the lowest N, P and K uptake (7.19, 2.07 and 7.44 kg

ha^{-1}) by weeds which were found at par with rest of the herbicide treatments except hand weeding at 25 and 50 DAS (W_2) and weedy (W_1) treatment in case of P and K uptake only (Table 5).

In 2019-20, among herbicides, application of Pendimethalin 1.0 kg a.i. ha^{-1} PE *fb* Quizalofop 60 g a.i. ha^{-1} PoE (W_4) registered significantly the lowest N, P and K uptake (7.08, 2.07 and 6.83 kg ha^{-1}) by weeds which were found at par with Pendimethalin 30 EC 1.0 kg a.i. ha^{-1} PE *fb* Clodinafop 15 WP @ 60 g a.i. ha^{-1} PoE (W_5) (Table 5).

The effective control of broad-leaved weeds was done due to combined activity of pre- and post-emergence herbicides (Sharma *et al*., 2007). Since uptake is a function of dry matter and content of the nutrients, it follows the trend of dry matter. Thus, nitrogen, phosphorus and potassium uptake by weeds was significantly affected under weed control treatments because of effective weed control, pendimethalin *fb* quizalofop and hand weeding twice remained at par resulted in significantly lower N, P and K removal by weeds. The lower uptake of N, P and K by weeds was due to their effective control by pre- and post-emergence herbicide activity (Nepalia and Jain, 2000).

Table 6: Interaction effect of nutrient and weed management on N uptake (kg ha^{-1}) by weeds at 60 DAS during 2018-19

Weed management / Nutrient Levels	W_1- Weedy	W_2- Two HW at 25 & 50 DAS	W_3- Pendimethalin 1.0 kg a.i. ha^{-1}	W_4-Pendimethalin 1.0 kg a.i. ha^{-1} PE + Quizalofop 60 g a.i. ha^{-1} PoE	W_5- Pendimethalin 1.0 kg a.i. ha^{-1} PE + Clodinafop 60 a.i. ha^{-1} PoE	W_6- Oxyflourfen 150 g a.i. ha^{-1}	W_7- Oxyflourfen 150 g a.i. ha^{-1} + Quizalofop 60 g a.i. ha^{-1} PoE	W_8- Oxyflourfen 150 g a.i. ha^{-1} + Clodinafop 60 g a.i. ha^{-1} PoE
N_1-Soil test RDF 100:40:40:20:6.25 kg NPKSZn ha^{-1}	22.33	0.00	9.22	7.06	7.14	11.93	7.94	9.22
N_2-100% RDF 80:40:40:20:5 kg NPKSZn ha^{-1}	23.37	0.00	10.62	9.74	9.82	14.66	10.63	10.95
N_3-125% RDF 100:50:50:25:6.25 kg NPKSZn ha^{-1}	18.73	0.00	6.67	4.76	4.89	9.32	5.34	7.49
SEm±	0.64				0.84			
CD (P=0.05)	1.83 (Levels of W at same level of N)				2.84 (Levels of W at same level of N)			

In 2018-19, application of Pendimethalin 1.0 kg a.i. ha^{-1} PE *fb* Quizalofop 60 g a.i. ha^{-1} PoE with 125% RDF (N_3W_4) exhibited the lowest K uptake (5.33 kg ha^{-1}) by weeds which was found at par with rest of the herbicide treatments except hand weeding at 25 and 50 DAS with 125% RDF (N_3W_2) and weedy plot with 125% RDF (N_3W_1) treatment (Table 7).

N, P and K uptake by weeds varied significantly due to weed management practices. Weeds had lower N, P and K uptake than that of mustard crop. The highest N, P and K uptake by weeds was observed in weedy check and the lowest uptake by two hand weeding 20 and 40 DAS. Reduction in N, P and K uptake by weeds under two hand weeding might be due to lower density and dry weight of weeds which eventually led to higher uptake of these nutrients by mustard crop. The results of highest N, P and K uptake by weeds are in accordance with the findings of Kour *et al*. (2013) and Mukherjee (2014). This indirectly by reducing nutrient uptake by weeds due to lower weed density and dry matter, these treatments were the best in controlling weeds.

In 2019-20, hand weeding at 25 and 50 DAS with 125% RDF (N_3W_2) exhibited N uptake by weeds of zero value which was significantly lower than weedy plot with 125% RDF (N_3W_1). Application of Pendimethalin 1.0 kg a.i. ha^{-1} PE *fb* Quizalofop 60 g a.i. ha^{-1} PoE with 125% RDF (N_3W_4) exhibited the lowest N uptake (4.42 kg ha^{-1}) by weeds which was found at par with N_3W_5 and N_3W_7 and was significantly inferior to rest of the treatments (Table 8).

Table 7: Interaction effect of nutrient and weed management on K uptake (kg ha^{-1}) by weeds at 60 DAS during 2018-19

Weed management / Nutrient Levels	W_1- Weedy	W_2- Two HW at 25 & 50 DAS	W_3- Pendi methalin 1.0 kg a.i. ha^{-1}	W_4-Pendi methalin 1.0 kg a.i. ha^{-1} PE + Quizalofop 60 g a.i. ha^{-1} PoE	W_5- Pendi methalin 1.0 kg a.i. ha^{-1} PE + Clodinafop 60 a.i. ha^{-1} PoE	W_6- Oxyflourfen 150 g a.i. ha^{-1}	W_7- Oxyflourfen 150 g a.i. ha^{-1} + Quizalofop 60 g a.i.ha^{-1} PoE	W_8- Oxyflourfen 150 g a.i. ha^{-1} + Clodinafop 60 g a.i. ha^{-1} PoE
N_1-Soil test RDF 100:40:40:20:6.25 kg NPKSZn ha^{-1}	19.68	0.00	8.96	6.16	7.35	9.46	8.14	8.29
N_2-100% RDF 80:40:40:20:5 kg NPKSZn ha^{-1}	20.66	0.00	11.04	10.16	10.67	11.13	11.14	12.28
N_3-125% RDF 100:50:50:25:6.25 kg NPKSZn ha^{-1}	13.67	0.00	6.83	6.00	5.33	7.48	6.14	5.38
SEm±	0.94				0.97			
CD (P=0.05)	2.69 (Levels of W at same level of N)				2.97 (Levels of N at same level of W)			

Table 8: Interaction effect of nutrient and weed management on N uptake (kg ha^{-1}) by weeds at 60 DAS during 2019-20

Weed management / Nutrient Levels	W_1- Weedy	W_2- Two HW at 25 & 50 DAS	W_3- Pendi methalin 1.0 kg a.i. ha^{-1}	W_4-Pendi methalin 1.0 kg a.i. ha^{-1} PE + Quizalofop 60 g a.i. ha^{-1} PoE	W_5- Pendi methalin 1.0 kg a.i. ha^{-1} PE + Clodinafop 60 a.i. ha^{-1} PoE	W_6- Oxyflourfen 150 g a.i. ha^{-1}	W_7- Oxyflourfen 150 g a.i. ha^{-1} + Quizalofop 60 g a.i.ha^{-1} PoE	W_8- Oxyflourfen 150 g a.i. ha^{-1} + Clodinafop 60 g a.i. ha^{-1} PoE
N_1-Soil test RDF 100:40:40:20:6.25 kg NPKSZn ha^{-1}	25.04	0.00	11.92	9.74	9.82	14.66	10.63	11.61
N_2-100% RDF 80:40:40:20:5 kg NPKSZn ha^{-1}	22.33	0.00	9.22	7.06	7.14	11.93	7.94	9.22
N_3-125% RDF 100:50:50:25:6.25 kg NPKSZn ha^{-1}	19.73	0.00	6.67	4.42	4.56	9.32	5.34	6.66
SEm±	0.43				0.88			
CD (P=0.05)	1.64 (Levels of W at same level of N)				3.33 (Levels of N at same level of W)			

Mukherjee *et al*. (2014) conducted trial on the influence of weed and fertilizer management on nutrient uptake in mustard. All weed management treatments significantly reduced nutrient uptake by weeds. Minimum nutrient uptake by weeds was recorded under pendimethalin *fb* quizalofop being at par with hand weeding. These results corroborated with the findings of Punia *et al*. (2010) and Prusty *et al*. (2018).

In 2019-20, hand weeding at 25 and 50 DAS with 125% RDF (N_3W_2) exhibited P uptake by weeds of zero value which was significantly lower than weedy plot with 125% RDF (N_3W_1). Application of Pendimethalin 1.0 kg a.i. ha^{-1} PE *fb* Quizalofop 60 g a.i. ha^{-1} PoE with 125% RDF

(N_3W_4) exhibited the lowest P uptake (1.44 kg ha^{-1}) by weeds which was found at par with N_3W_5, N_3W_8 and N_3W_7 and was significantly inferior to rest of the treatments (Table 9).

Table 9: Interaction effect of nutrient and weed management on P uptake (kg ha^{-1}) by weeds at 60 DAS during 2019-20

Weed management / Nutrient Levels	W_1-Weedy	W_2-Two HW at 25 & 50 DAS	W_3-Pendi methalin 1.0 kg a.i. ha^{-1}	W_4-Pendi methalin 1.0 kg a.i. ha^{-1} PE + Quizalofop 60 g a.i. ha^{-1} PoE	W_5- Pendi methalin 1.0 kg a.i. ha^{-1} PE + Clodinafop 60 a.i. ha^{-1} PoE	W_6-Oxyflourfen 150 g a.i. ha^{-1}	W_7-Oxyflourfen 150 g a.i. ha^{-1} + Quizalofop 60 g a.i.ha^{-1} PoE	W_8-Oxyflourfen 150 g a.i. ha^{-1} + Clodinafop 60 g a.i. ha^{-1} PoE
N_1-Soil test RDF 100:40:40:20:6.25 kg NPKSZn ha^{-1}	7.13	0.00	3.94	2.72	3.03	3.31	3.20	3.09
N_2-100% RDF 80:40:40:20:5 kg NPKSZn ha^{-1}	6.44	0.00	2.94	2.04	2.15	2.46	2.31	2.25
N_3-125% RDF 100:50:50:25:6.25 kg NPKSZn ha^{-1}	5.85	0.00	2.34	1.44	1.54	1.86	1.76	1.63
SEm±	0.11				0.12			
CD (P=0.05)	0.36 (Levels of W at same level of N)				0.38 (Levels of N at same level of W)			

Table 10: Interaction effect of nutrient and weed management on K uptake (kg ha^{-1}) by weeds at 60 DAS during 2019-20

Weed management / Nutrient Levels	W_1-Weedy	W_2-Two HW at 25 & 50 DAS	W_3-Pendi methalin 1.0 kg a.i. ha^{-1}	W_4-Pendi methalin 1.0 kg a.i. ha^{-1} PE + Quizalofop 60 g a.i. ha^{-1} PoE	W_5- Pendi methalin 1.0 kg a.i. ha^{-1} PE + Clodinafop 60 a.i. ha^{-1} PoE	W_6-Oxyflourfen 150 g a.i. ha^{-1}	W_7-Oxyflourfen 150 g a.i. ha^{-1} + Quizalofop 60 g a.i. ha^{-1} PoE	W_8-Oxyflourfen 150 g a.i. ha^{-1} + Clodinafop 60 g a.i. ha^{-1} PoE
N_1-Soil test RDF 100:40:40:20:6.25 kg NPKSZn ha^{-1}	21.66	0.00	12.84	10.16	11.33	13.46	12.14	11.95
N_2-100% RDF 80:40:40:20:5 kg NPKSZn ha^{-1}	23.35	0.00	8.96	6.16	7.35	9.46	8.14	7.96
N_3-125% RDF 100:50:50:25:6.25 kg NPKSZn ha^{-1}	12.34	0.00	6.83	4.16	5.33	7.48	6.14	5.98
SEm±	0.82				0.98			
CD (P=0.05)	2.83 (Levels of W at same level of N)				3.39 (Levels of N at same level of W)			

The highest removal of nutrients (N, P and K) by weeds were recorded under weedy plot, whereas the lowest nutrient depletion by weeds were recorded under hand weeding treatment and pendimethalin @ 1.0 kg a.i. ha^{-1} PE *fb* quizalofop 60 g a.i. ha^{-1} PoE. Similar results were reported by Patel (2000) in pigeonpea and Chauhan (2000) in chickpea.

In 2019-20, hand weeding at 25 and 50 DAS with 125% RDF (N_3W_2) exhibited the lowest K uptake by weeds of zero value being significantly lower than N_3W_1. Pendimethalin 1.0 kg a.i. ha^{-1} PE *fb* Quizalofop 60 g a.i. ha^{-1} PoE with 125% RDF (N_3W_4) exhibited the lowest K uptake (4.16 kg ha^{-1})

by weeds which was found at par with rest of the treatments except N_3W_6 and N_3W_1 (Table 10). The removal of N, P and K by weeds were reduced significantly by herbicidal and manual weeding and it almost nil under hand weeding. These results conformed the findings of Kour *et al*. (2013) and Singh (2015).

CONCLUSION

Thus, it might be concluded that pendimethalin @ 1.0 kg a.i. ha^{-1} PE *fb* quizalofop @ 60 g a.i. ha^{-1} PoE along with 125% RDF (100:50:50:25:6.25 kg NPKSZn ha^{-1}) enhanced N, P and K uptake by crop though hand weeding at 25 and 50 days of sowing along with 125% RDF (100:50:50:25:6.25 kg NPKSZn ha^{-1}) exhibited significant improvement in nutrient uptake by crop over weedy and herbicide treatments.

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