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Influence of Different Herbicide Levels on Nutrient Removal by Weeds and Uptake by Potato (*Solanum tuberosum* L.)

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Authors' contributions

This work was carried out in collaboration between all authors. Author RH designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors RJ and GP managed the analyses of the study. Author RJ managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was conducted during *kharif* 2016 at College of Agriculture, Hassan, University of Agricultural Sciences, Bengaluru to evaluate different pre and post emergent herbicides on nutrient removal by weeds and uptake by Potato (*Solanum tuberosum* L.) the soil of experimental site is red sandy loam in texture, neutral in reaction and medium in available nitrogen and potassium, high in available phosphorus. The experiment was laid out in a RCBD with seven treatments replicated thrice. The investigation revealed that, among different herbicides, lower removal of N, P_2O_5 and K_2O by weeds were recorded by application of Fenoxaprop–p-ethyl 54 g a.i. ha^{-1} as early post emergent (12.26, 4.12 and 11.47 kg ha^{-1}) which was on par with the application of Quizalofop–p-ethyl 30 g a.i. ha^{-1} as early post emergent (13.58, 4.61 and 12.53 kg ha^{-1}). Significantly higher total nutrient uptake by potato were recorded by (91.15, 30.75 and 94.70 kg N, P_2O_5 and K_2O ha^{-1} at harvest, respectively) by Fenoxaprop–p-ethyl 54 g a.i. ha^{-1} as early post emergent, closely followed by Quizalofop–p-ethyl 30 g a.i. ha^{-1} as early post emergent (89.47, 29.50 and 93.12 kg N, P_2O_5 and K_2O ha^{-1} at harvest, respectively).

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1. INTRODUCTION

Potato (*Solanum tuberosum* L.) is one of the most important vegetable cum food crops of the world. Potato is cultivated in 2.13 m ha^{-1} in India, with a production of 43.7 m t and productivity of 20.5 MT ha^{-1} [1]. Potato is a short duration crop; therefore, it fits in well for rotation with cereals, vegetables, pulses, or oilseed crops. At present, potato is grown in about 15 countries of the world on a wide range of soils and agro climatic conditions [2]. In Karnataka it is grown as rainfed crop in Hassan, Belgaum, Dharwad and Chikkamagaluru districts during *Kharif* (June to September) and as an irrigated crop during *rabi* (November to February) in the districts of Kolar, Chikkaballapura and Bengaluru rural. Hassan and Chikkamagaluru are the major potato producing districts under southern transitional zone of Karnataka contributing nearly 60 per cent of the total production in the state [3].

There are several constraints in potato production, of which weeds often pose a serious problem. It is a very poor competitor with weeds because of its extremely slow growth in the initial emergence phase. The yield reduction due to weeds in potato is estimated to be as high as 10 to 80 per cent [4]. So, control of weeds in the initial stages appears imperative as it plays an important role in maximizing the tuber production. Use of suitable herbicides alone or in combination with manual or mechanical weeding for weed control reduce the cost towards weed control by 75-85 per cent compared to manual weeding [5].

2. MATERIALS AND METHODS

A field experiment was conducted during *kharif* 2016 at College of Agriculture, Hassan, University of Agricultural Sciences, Bengaluru. The experimental site is geographically situated in the Southern Transitional Zone (Zone - 7) of Karnataka and located between 12º 13' and 13º 33' N Latitude and 75º 33' and 76º 38' E Longitude at an altitude of 827 m above Mean Sea Level (MSL). The soil of the experimental site was red sandy loam. The experiment was laid out in randomized block design with seven treatments and replicated thrice. The treatments comprised of four herbicide levels, conventional weed control practices followed by the farmers and check treatments *Viz*., weedy check and weed free check.

2.1 Weed Flora Observed in Experimental Site

The major weed flora observed in the experimental fields were *Cyperus rotundus* (among sedge), *Cynodon dactylon* (among grasses), while among broad leaf weeds *Commelina benghalensis*, *Ameranthus viridis, Chinapodium album.*

2.2 Soil and Its Characters

The soil of the experimental site was red sandy loam. The initial soil sample was drawn from the experimental site. Sample was air dried, powdered, sieved and stored in polythene cover for further physical and chemical analysis.

2.3 Chemical Analysis of Crop and Weed Samples

Potato plant samples and weed samples at harvest were collected from each plot. These were washed with distilled water, air dried and then dried in oven at 60-70℃ till the constant weight was obtained and finally ground separately in grinder. The ground material was collected in butter paper bags and later used for chemical analysis. Nitrogen content in the composite sample (haulms, leaves and tubers), weeds and crop leaf fall was estimated by modified micro Kjeldhal's method [6] and expressed in per cent.

For analysis of phosphorus and potassium, plant sample were pre digested with concentrated HNO_3 and tri-acid mixture (HNO_3: $HCLO_4$: H_2SO_4 at 10:4:1) which were used for digestion of composite weed and plant samples. Phosphorus content in samples was determined by vanadomolybdo-phosphoric yellow colour method by using spectrophotometer at 470 nm [6] and expressed in percentage and converted into kg ha^{-1} based on dry matter.

Potassium content in crop and weed sample was determined by flame photometric method [6] and was expressed in percentage.

The uptake of nitrogen, phosphorus and potassium was calculated for crop and weeds for each treatment separately by using the following formula and expressed in kg ha^{-1}.

Nutrient uptake =

$$\frac{\text{Nutrient concentration (\%)}}{100} \times \text{Dry matter weight (kg ha}^{-1}\text{)}$$

The data was statistically analyzed by following the method of [7]. Critical difference for the significant source of variation was calculated at five per cent level of significance. Treatment differences those were not significant were denoted by NS.

3. RESULTS AND DISCUSSION

3.1 Nutrient Uptake by Potato at Harvest

Significantly higher total nutrient uptake by potato (92.07, 31.61 and 96.10 kg N, P_2O_5 and K_2O ha^{-1} at harvest, respectively) were recorded in T_7 *i.e.,* Weed free check. Among herbicide treatments, significantly higher total nutrient uptake by potato were recorded by (91.15, 30.75 and 94.70 kg N, P_2O_5 and K_2O ha^{-1} at harvest, respectively) T_3 *i.e.,* Fenoxaprop–p-ethyl 54 g a.i. ha^{-1} as early post emergent, closely followed by T_4 *i.e.,* Quizalofop–p-ethyl 30 g a.i. ha^{-1} as early post emergent (89.47, 29.50 and 93.12 kg N, P_2O_5 and K_2O ha^{-1} at harvest, respectively). Whereas, T_6 *i.e.,* Weedy check recorded significantly lower total nutrient uptake by potato (72.30, 21.0 and 82.10 kg N, P_2O_5 and K_2O ha^{-1} at harvest, respectively). Higher uptake of nutrients by crop in these treatments was due to less weed population and their dry weight which helped the crop to grow in weed free environment and absorb more nutrients from the soil. Whereas, weedy check recorded significantly lower uptake of nutrients by the crop. It was due to more crop weed competition for nutrients. Similar observations were reported by [8,9,10].

3.2 Nutrient Removal by Weeds at Harvest

Significantly higher total nutrient removal by weeds (84.40, 38.57 and 98.60 kg N, P_2O_5 and K_2O ha^{-1} at harvest, respectively) were recorded in T_6 *i.e.,* Weedy check. Among herbicide treatments, significantly lower total nutrient removal by weeds were recorded by (12.26, 4.12 and 11.47 kg N, P_2O_5 and K_2O ha^{-1} at harvest, respectively) T_3 *i.e.,*Fenoxaprop–p-ethyl 54 g a.i. ha^{-1} as early post emergent, closely followed by T_4 *i.e.,* Quizalofop–p-ethyl 30 g a.i. ha^{-1} as early post emergent (13.58, 4.61 and 12.53 kg N, P_2O_5 and K_2O ha^{-1} at harvest, respectively). The potato crop yield is negatively correlated with nutrient removal by weeds. As the weed growth increases, the nutrient removal by weeds will also increase. The weeds take upper hand suppresses crop growth and development which ultimately reflects in terms of poor yield. The lower removal of nutrients by weeds in the above treatments was due to better control of weeds which resulted in low weed population and their dry weight. Whereas, weedy check registered more removal of nutrients by weeds. This was due to poor control of weeds which facilitated the weeds to grow and utilize nutrients to maximum extent. Similar results were also reported by [10].

3.3 Nutrient Status of Soil at Harvest

Significantly higher nitrogen, phosphorus and potassium content of soil was observed in treatment T_7 *i.e.,* Weed free check (287.0, 68.0 and 187.30 kg ha^{-1}, respectively). Among herbicide treatments, significantly higher

Table 1. Physico-chemical properties of soil in the experimental site

Particulars	Values	Status	Method followed
I. Physical properties			
1.Sand	65.8%	-	International pipette method [11]
2.Silt	7.4%	-	
3.Clay	25.8%	-	
4.Soil textural class	Red sandy loam		
II. Chemical properties			
1. pH (1:2.5)	7.08	Neutral	Potentiometric method [6]
2. EC (1:2.5) (dSm^{-1})	0.22	Low	Conductometric method [6]
3. Organic carbon (%)	0.48	Low	Wet oxidation method [12]
4. Available N (kg ha^{-1})	334.3	Medium	Alkaline potassium permanganate method [13]
5. Available P_2O_5 (kg ha^{-1})	54.8	High	Bray's extract [6]
6. Available K_2O (kg ha^{-1})	223.0	Medium	Flame photometry [6]

Table 2. Effect of different levels of herbicides on nutrient uptake by tubers, haulms and total nutrient uptake in potato at harvest

Treatments		Tubers (kg ha^{-1})			Haulms (kg ha^{-1})			Total (kg ha^{-1})		
		N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O
T_1	Farmers practice	78.10	23.13	78.70	2.90	0.60	7.30	81.00	23.73	86.00
T_2	Metribuzin 500 g a.i. ha^{-1} as PE	83.80	27.00	83.60	3.42	0.86	7.60	87.22	27.86	91.20
T_3	Fenoxaprop –p-ethyl 54 g a.i. ha^{-1} as EPE	87.40	29.70	86.60	3.75	1.05	8.10	91.15	30.75	94.70
T_4	Quizalofop –p-ethyl 30 g a.i. ha^{-1} as EPE	85.87	28.50	85.32	3.60	1.00	7.80	89.47	29.50	93.12
T_5	Paraquat dichloride 480 g a.i. ha^{-1} as EPE	81.60	25.47	81.20	3.20	0.78	7.45	84.80	26.25	88.65
T_6	Weedy check	70.10	20.60	75.00	2.20	0.40	7.10	72.30	21.00	82.10
T_7	Weed free check	88.17	30.50	87.80	3.90	1.12	8.30	92.07	31.61	96.10
S.Em±		1.36	0.65	1.20	0.11	0.05	0.17	1.36	0.78	1.25
LSD(*p*=0.05)		4.18	2.01	3.71	0.35	0.15	0.53	4.19	2.41	3.84

Note: PE: Pre-emergent application; EPE: Early post emergent application; BLW: Broad leaf weeds; DAP-Days after planting

Table 3. Effect of different levels of herbicides on nitrogen, phosphorus and potassium removal by weeds (kg ha^{-1}) at harvest

Treatments		N	P_2O_5	K_2O
T_1	Farmers practice	28.70	12.63	39.97
T_2	Metribuzin 500 g a.i. ha^{-1} as PE	15.40	5.53	14.60
T_3	Fenoxaprop –p-ethyl 54 g a.i. ha^{-1} as EPE	12.26	4.12	11.47
T_4	Quizalofop –p-ethyl 30 g a.i. ha^{-1} as EPE	13.58	4.61	12.53
T_5	Paraquat dichloride 480 g a.i. ha^{-1} as EPE	16.89	6.10	16.97
T_6	Weedy check	84.40	38.57	98.60
T_7	Weed free check	0.00	0.00	0.00
S.Em±		0.77	0.33	0.37
LSD(*p*=0.05)		2.36	1.01	1.15

Note: PE: Pre-emergent application; EPE: Early post emergent application; BLW: Broad leaf weeds; DAP-Days after planting

Table 4. Effect of different levels of herbicides on nitrogen, phosphorus and potassium status of the soil (kg ha^{-1}) at harvest

Treatments		N	P_2O_5	K_2O
T_1	Farmers practice	268.00	58.00	158.20
T_2	Metribuzin 500 g a.i. ha^{-1} as PE	278.00	64.00	179.27
T_3	Fenoxaprop –p-ethyl 54 g a.i. ha^{-1} as EPE	281.00	67.00	181.00
T_4	Quizalofop –p-ethyl 30 g a.i. ha^{-1} as EPE	280.00	65.00	180.10
T_5	Paraquat dichloride 480 g a.i. ha^{-1} as EPE	275.50	62.00	178.10
T_6	Weedy check	206.30	39.80	101.21
T_7	Weed free check	287.00	68.00	187.30
S.Em±		3.10	1.45	3.34
LSD(*p*=0.05)		9.54	4.48	10.30

Note: PE: Pre-emergent application; EPE: Early post emergent application; BLW: Broad leaf weeds; DAP-days after planting

nitrogen, phosphorus and potassium content of soil was observed by application of Fenoxaprop–p-ethyl 54 g a.i. ha^{-1} as early post emergent (281.0, 67.0 and 181.30 kg ha^{-1}, respectively). Whereas, significantly lower nitrogen, phosphorous and potassium content of soil was recorded in weedy check (206.3, 39.80 and 101.21 kg ha^{-1}, respectively). Higher nutrient

status of soil in the above treatments was due to less weed population and their dry weight which helped the crop to grow in weed free environment. Whereas, weedy check noticed lower nutrient status of soil. This is mainly because of more crop weed competition for nutrients.

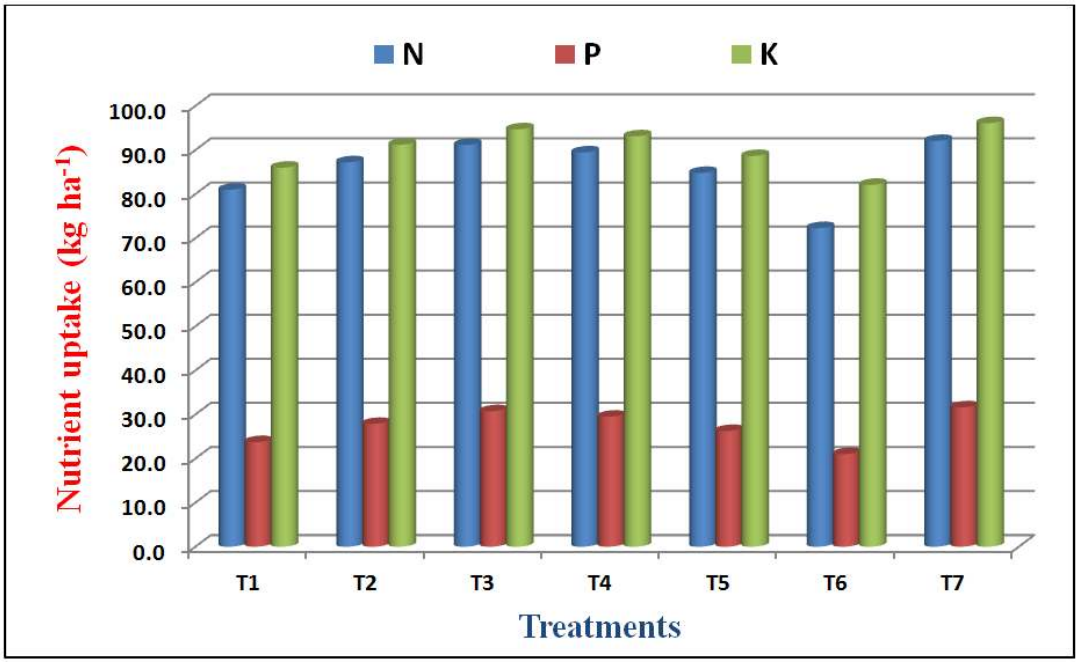

Fig. 1. Nutrient uptake (kg ha^{-1}) by potato at harvest as influenced by weed management practices

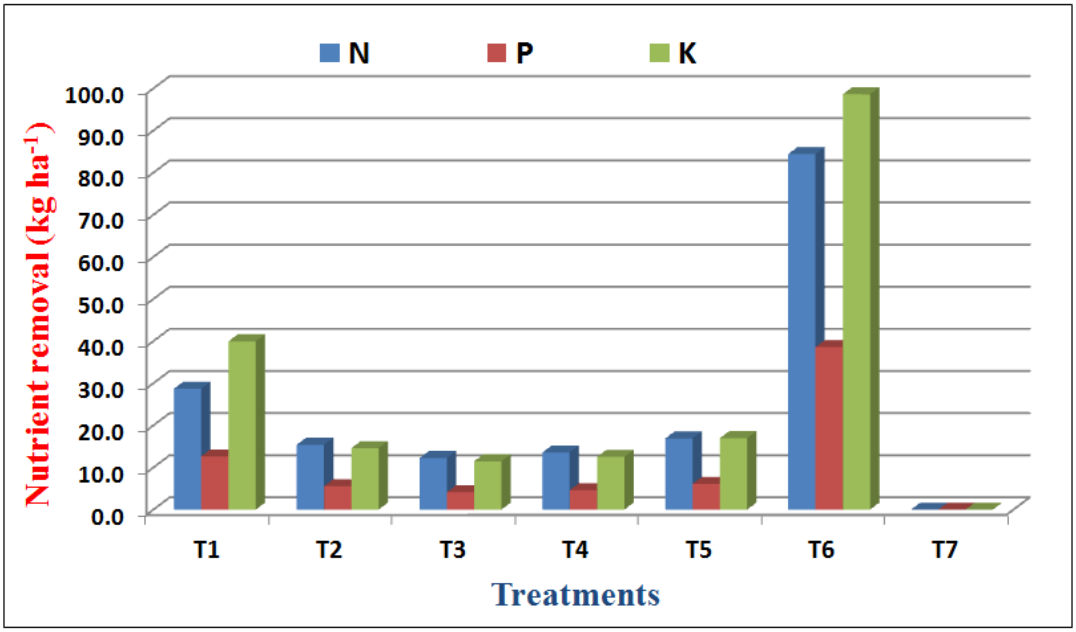

Fig. 2. Nutrient removal (kg ha^{-1}) by weeds at harvest as influenced by weed management practices

4. CONCLUSION

The study concluded that higher nutrient uptake by potato (91.15, 30.75 and 94.70 kg N, P_2O_5 and K_2O ha^{-1} at harvest, respectively), lower nutrient removal by weeds (12.26, 4.12 and 11.47 kg N, P_2O_5 and K_2O ha^{-1} at harvest, respectively) at harvest were recorded by application of Fenoxaprop–p-ethyl 54 g a.i. ha^{-1} as early post emergent as compared to the weedy check except weed free check.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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