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NUTRIENT REMOVAL BY CROP AND WEEDS AS INFLUENCED BY NON-CHEMICAL METHODS OF WEED MANAGEMENT IN KODO MILLET (*PASPALUM SCROBICULATUM* L.)

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ABSTRACT

A field experiment was conducted at Research Institute of Organic Farming field unit, University of Agricultural Sciences, Gandhi Krishi Vignan Kendra, Bengaluru during *Kharif* (rainy season) of 2021 to evaluate different non-chemical methods of weed management in irrigated kodo millet (*Paspalum scrobiculatum* L.). The experiment was laid out in randomized complete block design with 12 treatments, replicated 3 times. Among various methods, hand weeding at 20 and 40 DAS recorded significantly lower weed density, lower weed dry weight, lower weed index and higher weed control efficiency. Stale seed bed technique *fb* inter cultivation twice at 25 and 45 DAS and Kodo millet + fodder cowpea as intercrop with in-situ mulching at 35 DAS *fb* 1 intercultivation at 40 DAS prevented excess growth of weeds which resulted in reduced removal of nutrients from soil by weeds but increased in uptake of nutrient by crop.
Keywords **:** Nutrient removal, Weeds, Kodo millet.

Introduction

Kodo millet is an annual grain (*Paspalum scrobiculatum* L.) belonging to the family Poaceae. It is known a s haraka (in kannada), cow grass, rice grass, ditch millet, native paspalum, Indian crown grass, known to be originated from tropical Africa, and it is estimated to be domesticated in India 3000 years ago. It is an important staple food grain in semi-arid areas, where hardly any cereal crop can be grown. It is a long duration crop (125-135 days) with relatively low water requirement and sometimes it is used as an intercrop. The productivity of kodo millet is affected largely by biotic stress *i.e.*, weed and hence weeds are considered as main hurdle in the cultivation during kharif season. Weeds compete with crop plants for nutrients, moisture, space and light and reduce not only the crop yields but also quality of produce accounting a loss of about 37 per cent in agricultural produce depending upon factors like type of weed flora and its density in standing crop in India (Yaduraju, 2006). Now a days herbicidal pollution and its residue in grains has brought consciousness among consumers about their health which needs to be considered by farmers. So ecofriendly measures to control the growth of weeds need to be evaluated which is both effective in managing weeds and also adaptable by farmers during cultivation.

Material and Methods

Field experiment was carried out at Research Institute of Organic Farming field unit, University of Agricultural Sciences, Gandhi Krishi Vignan Kendra, Bengaluru to evaluate different non-chemical methods of weed management in kodo millet against control of complex weed flora in irrigated kodo millet. The experimental site is located in agro climatic zone V (Eastern Dry zone) of Karnataka at a latitude of 13° 05' North, a longitude 77° 34' East and at an altitude of 924 meters above mean sea level. The normal annual rainfall of the station was 921 mm and the major part of rain was received between May to October and maximum rainfall was received during September and October months. The normal mean minimum air temperature ranged between 14.1ºC to 20.5ºC. Whereas, normal mean maximum air temperature ranged from 26.3°C to 33.8°C. The normal mean sunshine hours varied from 4.4 to 9.6 hours and normal mean monthly maximum relative humidity ranged from 77 to 89.0 per cent. The soil of the experimental site was sandy loam and was neutral in reaction (pH 6.58) with low electrical conductivity (0.24 dS m^{-1}) and medium organic carbon content (0.59%). The soil was low in available nitrogen (307 kg ha^{-1}), medium in available phosphorus (38.7 kg ha^{-1}) and available potassium (197.2 kg ha^{-1}).

The experiment was laid out in Randomized Block Design (RBD) with twelve treatments, replicated three times. The weed management practices included in the investigation were T_1 - inter cultivation at 25 DAS + 1 hand weeding at 45 DAS, T_2 - stale seed bed technique + inter cultivation twice at 25 and 45 DAS, T_3 - straw mulching @ 5 t ha^{-1} at 10-15 DAS, T_4-kodo millet + fodder cowpea as intercrop +1 inter cultivation at 30 DAS, T_5 - kodo millet + fodder cowpea as smothering crop in between rows of kodo millet, T_6 - kodo millet + fodder cowpea as intercrop with in-situ mulching at 35 DAS + 1 intercultivation at 40 DAS, T_7 - mechanical (cycle weeder) weeding at 35 DAS, T_8-two mechanical (cycle weeder) weeding at 20 and 40 DAS, T_9-cucumber leaf extract spray @100 ml/l, one at 2-4 leaf stage and another spray depending on the weed density, T_{10}-*Ageratum conyzoides* leaf extract spray @100 ml/l, one at 2-4 leaf stage and another spray depending on the weed density, T_{11}-weed free check (hand weeding at 20 and 40 DAS) and T_{12}-unweeded check (weedy check).

Biometric observations on weed density, weed dry weight, weed control efficiency at 30, 60, 90 DAS and at harvest, nutrient removal by weeds were recorded. Plant growth observations like plant height, leaf area, dry matter production, LAI and number of tillers $plant^{-1}$, yield components like panicle length, test weight, number of productive tillers were recorded. Nutrient removal by weeds and crop at harvest was recorded.

Plant samples of crop and weeds were collected from the field at the time of harvesting for studying nutrient uptake. They were dried at 60º C in hot air oven, powdered using grinder and subjected to chemical analysis to assess the removal of N, P and K. Chemical analysis of crop and weed samples for nitrogen, phosphorous, and potassium content was carried out for the computation of nutrient uptake by crops and nutrient removed by weeds. The values were expressed in kg ha^{-1}.

Results and Discussion

Weed flora

Major weed species found in the experimental plot were categorized into sedges, grasses and broad leaf weeds. Major sedge associated with crop was *Cyperus rotundus* L and grasses were *Digitaria marginata*, *Echinocloa colona* (L), *Dactyloctenium aegyptium* (L), *Eleusine indica* (L), *Cynodon dactylon* (L), *Panicum repens* (L), *Chloris barbata* (L.). Major broadleaved weeds observed were *Borreria hispida* (L), *Spilanthes acmella* (L), *Ageratum conyzoides* (L), *Alternanthera sessilis*, *Commelina benghalensis* (L), *Ionaidium supfruiticesum* (L), *Cleome viscose* (L), *Amaranthus viridis* (L), *Sida acuta*, *Acanthospermum hispida*, *Celosia argentea* (L), *Euphorbia geniculata*, *Portulaca oleracea* (L), *Oldenanadia corymbosa* (L) and *Phyllanthus niruri* (L) were dominant throughout the cropping period.

Several factors like initial weed seed bank, intensity of tillage operations during land preparation, weather parameters, earlier cropping system and soil health *etc* has influenced the emergence of different weed species during crop growth. Similar weed flora was reported by Patil *et al*. (2013), Kujur *et al*. (2015) and Mishra *et al*. (2018).

Nutrient removal by weeds

Weed's ability to remove nutrients was crucial for the cultivation of irrigated kodo millet. The removal of nutrients (nitrogen, phosphorus and potassium) was considerably influenced by non-chemical methods of weed management used, and it varied dramatically throughout the crop's growth phases.

Nitrogen removal

The effectiveness of the weed control treatment and the nutrient uptake by weeds were negatively correlated, and the nitrogen removal by weeds was

strongly influenced by different treatments and is shown in the Table 1. Among the treatments unweeded check (14.97 kg ha^{-1}) recorded higher nitrogen removal which was followed by kodo millet + fodder cowpea as smothering crop in between rows of kodo millet (10.93 kg ha^{-1}) and kodo millet + fodder cowpea as intercrop +1 inter cultivation at 30 DAS (10.73 kg ha^{-1}). Whereas significantly lower nitrogen removal was registered in weed free check (hand weeding at 20 and 40 DAS) (5.4 kg ha^{-1}) at harvest. The reduced weed density led to the decrease in the nitrogen removal by weeds in weed controlled plots.

Phosphorus removal

There was a discernible impact of no-chemical weed management strategies on weed's removal of phosphorus. Considerable differences were seen between treatments in terms of reduced uptake of P. Similar to nitrogen, phosphorus removal was lower in weed free check (hand weeding at 20 and 40 DAS) (2.6 kg ha^{-1}) which was comparable with Stale seedbed technique + inter cultivation twice at 25 and 45 DAS (2.7 kg ha^{-1}). Whereas significantly higher phosphorus removal by weeds was observed in unweeded check (6.07 kg ha^{-1}) followed by kodo millet + fodder cowpea as smothering crop in between rows of kodo millet (5.18 kg ha^{-1}). Uncontrolled weed growth led to increase in phosphorus removal by weeds. This is in accordance with the findings of Channa Naik *et al.* (2000).

Potassium removal

The amount of K that weeds depleted was significantly reduced across a range of weed management techniques. Among the methods, weed free check (hand weeding at 20 and 40 DAS) (3.7 kg ha^{-1}) significantly reduced K uptake by weeds which was comparable with stale seedbed technique + inter cultivation twice at 25 and 45 DAS (3.9 kg ha^{-1}) and inter-cultivation at 25 DAS + 1 hand weeding at 45 DAS (4.03 kg ha^{-1}). Unweeded check (9.27 kg ha^{-1}) recorded significantly higher potassium removal by weeds due to devoid of weed management measures in these plots.

In this experiment, the pattern of nutrient removal by weeds showed that the nutrient loss due to weeds was maximum wherever weed management practices were taken and nutrient loss was minimum where weed management practices were effectively carried out. In terms of weeds' ability to remove nutrients from crops, crop-weed interference is largely influenced by competition for resources. Nutrient removal by the weeds and yield of the kodo millet crop are negatively correlated, with increase in the weed growth and weed population nutrient removal by them also increases causing profuse growth of weeds which suppresses the growth and development of the crop leading to poor crop yields. The loss varies with the weed intensity, weed dry matter accumulation. Similar findings were reported by Vinothini and Arthanari (2021). Weed free check (hand weeding at 20 and 40 DAS) (T_{11}) recorded significantly lower uptake of nitrogen, phosphorous and potassium by weeds (Table 1). It is due to good suppression of weeds leading to lower weed population and weed dry weight during crop growth period. Unweeded check (T_{12}) recorded significantly higher removal of nitrogen, phosphorous and potassium by the weeds which may be due to luxuriant growth of weeds due to non-intervention to the growth of weeds by applying no weed control measures. These results were in accordance with the works of Pushplata (2013), Naveen *et al.* (2012) and Kumar *et al.* 2015.

Nutrient removal by crop (kodo millet)

Nutrient removal by kodo millet played an important role in producing higher yield as well as showing its competing ability with weeds. So it is necessary to understand removal of major nutrients by crop. All treatments were significantly varying with nutrient removal by kodo millet (Fig. 1).

Nitrogen removal

Nitrogen removal was well correlated with dry matter production by crop. All the weed management treatments recorded significantly higher nitrogen uptake as compared to unweeded check (14.33 kg ha^{-1}) which was lowest. Kodo millet in weed free check (hand weeding at 20 and 40 DAS) (48.0 kg ha^{-1}) recorded significantly higher nitrogen uptake compared to other treatments followed by stale seed bed technique + inter cultivation twice at 25 and 45 DAS (44.0 kg ha^{-1}) which was on par with inter cultivation at 25 DAS + 1 hand weeding at 45 DAS (43.33 kg ha^{-1}) (Fig. 1). Better control of weeds led to reduced weed-crop competition for nitrogen which resulted in higher uptake by crop in weed free check.

Phosphorus removal

Kodo millet grown in weed free check (hand weeding at 20 and 40 DAS) recorded significantly higher phosphorous uptake (13.63 kg ha^{-1}) as compared to unweeded check (4.23 kg ha^{-1}) with lowest phosphorous uptake. But phosphorous uptake in stale seed bed technique + inter cultivation twice at 25 and 45 DAS (10.63 kg ha^{-1}) was on par with inter cultivation at 25 DAS + 1 hand weeding at 45 DAS (10.17 kg ha^{-1}) (Table 1). Phosphorus helped for both root development and also energy storage in plant along with that it contributed to seed filling process

which increased the yield of crop.

Potassium removal

Significantly higher potassium uptake by kodo millet was recorded in weed free check (hand weeding at 20 and 40 DAS) (36.77 kg ha^{-1}) followed by stale seed bed technique + inter cultivation twice at 25 and 45 DAS (31.65 kg ha^{-1}) which was on par with inter cultivation at 25 DAS + 1 hand weeding at 45 DAS (29.63 kg ha^{-1}). Here potassium contributed to the quality of the economic produce due to which it is called quality element.

Higher uptake of nitrogen, phosphorus and potassium in kodo millet was observed in weed free check (hand weeding at 20 and 40 DAS) (T_{11}) followed by stale seed bed technique + inter cultivation twice at 25 and 45 DAS (T_2) which was on par with inter cultivation at 25 DAS + 1 hand weeding at 45 DAS (T_1) due to higher dry matter accumulation and higher nutrient content in the tissues. The nutrient uptake by crop and associated weeds follow an inverse relationship in a community. It was due to higher weed control efficiency that helped to suppress the weeds and resulted in reduced competition from weeds for nutrients, moisture, space and light leading to higher grain and straw yield. Unweeded check resulted in lower uptake of nitrogen, phosphorus and potassium which was due to higher crop weed competition for nutrients. Similar observations were recorded with the works of Kumar *et al*. 2015 and Madhukumar *et al*. 2013.

Higher nutrient uptake of crop in these treatments was mainly due to lower weed population and weed dry weight which helped the crop to grow well and absorb more nutrients from the soil and give less scope for loss nutrients from soil through weeds. Similar observations were also reported by Madhukumar *et al*. (2013), Ramana Murthy and Reddy (2013) and Gaganpreet *et al*. (2010) who reported significantly higher amount of NPK uptake with reduced competition by weeds. A favourable environment for greater crop nutrient uptake and a proportionate reduction in weed nutrient depletion are created by effective weed management practices.

Conclusion

From the experimentation, it is concluded that weed free check (hand weeding at 20 and 40 DAS) significantly reduced the nutrient removal (nitrogen, phosphorus & potassium) by weeds and increased nutrient uptake by kodo millet which enhanced the productivity of irrigated kodo millet. And unweeded plot recorded higher nutrient removal by weeds which drastically reduced the yield of kodo millet which shows that weeds are efficient in absorbing nutrients if left uncontrolled. When weeds are controlled effectively, the environment is more favorable for crops to absorb nutrients and weeds deplete nutrients at a proportionately lower rate. A significant component of crop-weed interference is competition for nutrients, which has an impact on weeds ability to remove nutrients from crops.

Table 1: Influence of non-chemical weed management practices on nutrient removal (kg ha^{-1}) by weeds and crop at harvest of kodo millet

Treatments	Weeds			Crop		
	N	P	K	N	P	K
Inter cultivation at 25 DAS + 1 hand weeding at 45 DAS	6.00	2.75	4.03	43.33	10.17	29.63
Stale seedbed technique + inter cultivation twice at 25 and 45 DAS	5.83	2.70	3.90	44.00	10.63	31.65
Straw mulching 5 t ha^{-1} at 10-15 DAS	8.23	4.17	5.10	30.00	8.23	22.07
Kodo millet + fodder cowpea as intercrop +1 inter cultivation at 30 DAS	10.73	4.47	6.57	24.33	6.77	17.93
Kodo millet + fodder cowpea as smothering crop in between rows of kodo millet	10.93	5.18	7.10	21.67	6.13	17.33
Kodo millet + fodder cowpea as intercrop with in-situ mulching at 35 DAS + 1 intercultivation at 40 DAS	6.53	3.00	4.23	38.33	8.67	27.60
Mechanical (cycle weeder) weeding at 35 DAS	8.80	4.07	5.63	27.67	7.80	21.10
Two mechanical (cycle weeder) weeding at 20 and 40 DAS	6.33	2.90	4.18	39.00	9.33	28.23
Cucumber leaf extract spray @100 ml/l, one at 2-4 leaf stage and another spray depending on the weed density	7.00	3.12	4.67	35.00	7.60	23.47
Ageratum conyzoides leaf extract spray @100 ml/l, one at 2-4 leaf stage and another spray depending on the weed density	7.13	3.18	4.80	34.67	7.40	23.03
Weed free check (hand weeding at 20 and 40 DAS)	5.40	2.60	3.70	48.00	13.63	36.77
Unweeded check (weedy check)	14.97	6.07	9.27	14.33	4.23	14.00
S.Em±	0.30	0.11	0.13	1.36	0.28	0.78
C.D. (P=0.05)	0.89	0.32	0.37	3.99	0.82	2.29

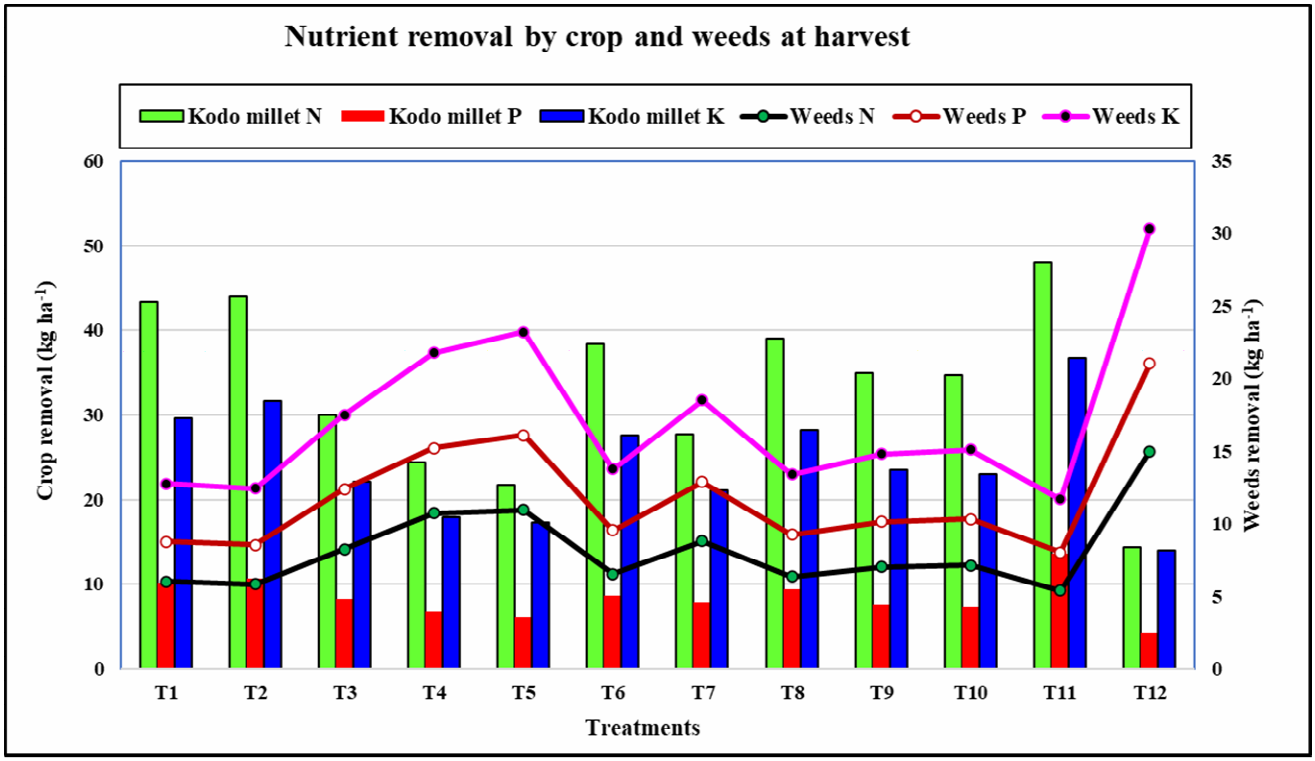

Fig. 1: Effect of different non-chemical methods of weed management on nutrient removal by crop and weeds at harvest in kodo millet

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