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Effect of weed management and phosphorus nutrition on yield of cowpea [*Vigna unguiculata* (L.) Walp.]

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Abstract
A field experiment was carried out during *kharif* 2019 at Instructional Farm of Agronomy, Rajasthan College of Agriculture, Udaipur to study the effect of weed management and phosphorus nutrition on yield of cowpea. Results revealed that minimum dry matter of weeds and the highest WCE, superior growth parameters, yield attributes and yield were recorded with pre-emergence application of pendimethalin 750 g ha^{-1} in combination with imazethapyr + imazamox 33.75 g ha^{-1} as post-emergence at 15-20 DAS next to weed free treatment. Whereas, application of 50 kg P_2O_5 ha^{-1} resulted in the highest dry matter of total weeds which was statistically at equivalence with application of 40 kg P_2O_5 ha^{-1} while, yield attributes and yield of cowpea pointedly increased with application of phosphorus at 40 kg P_2O_5 ha^{-1} compared to 30 kg P_2O_5 ha^{-1} at significant level and further addition of phosphorus from 40 to 50 kg P_2O_5 ha^{-1} failed to bring any significant improvement in these parameters.

Keywords: Cowpea, WCE, seed yield, phosphorus nutrition

1. Introduction
Cowpea is known for its versatility as it is used for grain, leaf and forage, cover crop and green manure crop. Being a leguminous pulse, it has high nutritive value and high palatability. Because of its nitrogen fixing ability, it is known for improving soil fertility (Abayomi and Abidoye, 2009) [1]. The world's estimated annual cowpea production is put at 4.5 million tonnes from an estimated land area of 12.6 million hectares. The productivity of the crop in Rajasthan is low and far below than its potential yield, possibly due to inadequate weed management as well as poor nutrition especially phosphorus fertilization. During rainy season, the crop suffers severely due to weed infestation resulting into wide range reduction in crop yield.

Scarcity of labours, un-workable soil conditions make manual weeding less effective and efficient during critical period. Hence, herbicidal weed control gains upper hand nowadays but it needs studies pertinent to the selectivity of different herbicides for this crop. Moreover, phosphorus application is also essential to get profitable yield as it influences root growth, nodule development, bacterial activity and nitrogen fixation. Keeping these facts in view, field study was planned with an objective to study the effect of weed management and phosphorus nutrition on yield of cowpea.

2. Materials and Methods
The experiment was conducted during *kharif* 2019 at Instructional Agronomy Farm of Rajasthan College of Agriculture, MPUAT, Udaipur. The soil of the experimental site was clay loam in texture with 288.00, 20.54 and 286.92 kg ha^{-1} available nitrogen, phosphorus and potassium, respectively, in 0-30 cm soil depth with pH 8.19. The experiment was laid out in factorial randomized block design with three replications and assigning 18 treatment combinations consisting of 6 weed management treatments (Pendimethalin 1000 g ha^{-1} PE *fb* hoeing and weeding 15-20 DAS, imazamox + imazethapyr 45 g ha^{-1} at 15-20 DAS, pendimethalin 750g ha^{-1} PE *fb* imazamox + imazethapyr 33.75 g ha^{-1} at15-20 DAS, one hoeing and weeding 15-20 DAS, weed free up to 50 days and weedy check) and 3 phosphorus doses (30, 40 and 50 kg P_2O_5 ha^{-1}). As per treatments, the needed quantities of fertilizers were applied below the seed at the time of sowing. Cowpea variety RC-101 was used as test crop with seed rate 15 kg ha^{-1} with recommended package of practices.

3. Results and Discussion

The experimental field was heavily infested with mixed flora of monocot and dicot weeds, *viz*. *Echinochloa colona* and *Cyperus rotundus* among monocot weeds and *Digera arvensis, Trianthema portulacastrum, Portulaca oleracea* and *Phyllanthus niruri* among dicot weeds.

3.1 Weed parameters

An examination of data (Table 1) implies that all the weed management treatments significantly reduced dry matter of total weeds at harvest compared to weedy check. The minimum dry matter of weeds was noticed with pre-emergence application of pendimethalin 750 g ha^{-1} in combination with imazethapyr + imazamox 33.75 g ha^{-1} as post-emergence at 15-20 DAS (535 kg ha^{-1}) next to weed free treatment (314 kg ha^{-1}). Because pre-emergenceapplication of pendimethalin 750 g ha^{-1} along with post-emergence application of imazethapyr + imazamox 33.75 g ha^{-1} at 15-20 DAS resulted in vigorous growth of crop which in turn caused smothering effect on late emerged weeds and thus this treatment was able to control weeds substantially throughout the crop growth next to weed free treatment. Results validate with the findings of Habimana *et al*. (2013a) [3]. With regard to phosphorus nutrition, application of 50 kg P_2O_5 ha^{-1} resulted in the highest dry matter of total weeds which was statistically at equivalence with application of 40 kg P_2O_5 ha^{-1}. This might be due to the fact that with more availability of phosphorus weeds accumulated more dry matter in them and also phosphorus helped in more uptake of nitrogen.

The highest WCE was recorded in weed free treatment (86.46%) which was followed by pre-emergence application of pendimethalin 750 g ha^{-1} along with post-emergence application of imazethapyr + imazamox 33.75 g ha^{-1} at 15-20 DAS (76.90%). This might be ascribed to the effective control of unwanted plants under these treatments, which reflected on lower weed dry matter at these stages of observation. This result is in agreement with the outcome of Jha and Soni (2013) [4]. Different doses of phosphorus have very slight difference amongst themselves for WCE at harvest.

3.2 Growth characters

A perusal of data (Table 1) indicates that all the weed management treatments consistently influenced plant dry matter accumulation and LAI at harvest. The highest plant dry matter accumulation was observed with weed free up 50 days (16.70 g $plant^{-1}$) which was statistically at par with pendimethalin 750 g ha^{-1} as pre-emergence in conjugation with imazethapyr + imazamox 33.75 g ha^{-1} as post-emergence (16.26 g $plant^{-1}$). This might be due to minimized competition of weeds with crop for resources and suppressed growth of weeds which enabled crop to accumulate more dry matter under these treatments.Maximum LAI was attained with weed free (5.67) treatment which was closely followed by pendimethalin 750 g ha^{-1} as pre-emergence in combination with imazethapyr + imazamox 33.75 g ha^{-1} as post-emergence (5.23). Probably, this is owing to better weed control resulted in favourable conditions to have greater uptake of nutrients and water reflected on full expansion of leaves and higher leaf area index. Thus, enhancement in these growth parameters is akin to those reported by Yadav *et al*. (2017) [6].

Application of phosphorus significantly influenced plant dry matter of cowpea at harvest up to 40 kg P_2O_5 ha^{-1} over 30 kg P_2O_5 ha^{-1} and further increase to 50 kg P_2O_5 ha^{-1} failed to enhance this parameter. Application of each successive doses of phosphorus significantly increased leaf area index of cowpea at harvest compared to their respective lower doses. Phosphorus also performs a crucial role in numerous physiological and biochemical processes which are of dynamic significance for growth and development of crop. As phosphorus helped in development of roots and nodulation which supported more nitrogen fixation by the crop thereby plant attained potential growth owing to ample availability of nitrogen and phosphorus. The results were in tune with research findings of Daramy *et al*. (2017) [2].

3.3 Yield attributes and Yield

Yield attributes like number of pods $plant^{-1}$ and seed yield $plant^{-1}$ significantly augmented owing to all weed management treatments over weedy check (Table 2). Weed free treatment resulted in the highest of all these yield attributes which was statistically at par with pendimethalin 750 g ha^{-1} as pre-emergence along with imazethapyr + imazamox 33.75 g ha^{-1} as post-emergence in all these yield attributes. Among the treatments, pre-emergence application of pendimethalin 750 g ha^{-1} accompanied by post-emergence application of imazethapyr + imazamox 33.75 g ha^{-1} recorded the highest seed and haulm yield of 736 and 1999 kg ha^{-1}, respectively and closely followed by pendimethalin 1000 g ha^{-1} along with hoeing and weeding at 15-20 DAS with seed and haulm yield of 732 and 1988 kg ha^{-1}, respectively. However, both these treatments were statistically at par with weed free treatment. The highest biological yield attained with weed free treatment (3038 kg ha^{-1}) followed by pendimethalin 1000 g ha^{-1} along with hoeing and weeding at 15-20 DAS (2855 kg ha^{-1}) and pendimethalin 750 g ha^{-1} as pre-emergence in combination with imazethapyr + imazamox 33.75 g ha^{-1} as post-emergence (2852 kg ha^{-1}). It can be described in the light of realities that these treatments controlled the weeds effectively, might have made more nutrients, space and soil moisture available to crop and thus enhanced seed and haulm yield of cowpea. This can be further explained on the basis of facts that these treatments remarkably controlled weeds in this way showing the highest weed control efficiency and documented the lowest weed index thus improving seed yield of cowpea.

Number of pods $plant^{-1}$ and seed yield $plant^{-1}$ pointedly increased with application of phosphorus at 40 kg P_2O_5 ha^{-1} compared to 30 kg P_2O_5 ha^{-1} at significant level and further addition of phosphorus from 40 to 50 kg P_2O_5 ha^{-1} failed to bring any significant improvement in these parameters. Enhanced seed and haulm yield of cowpea was obtained with application of 40 kg P_2O_5 ha^{-1} over 30 kg P_2O_5 ha^{-1} by 76 and 182 kg ha^{-1}, respectively and further addition of phosphorus from 40 to 50 kg P_2O_5 ha^{-1} failed to attain any significant enhancement in seed and haulm yield of cowpea. Application of phosphorus at 40 kg P_2O_5 ha^{-1} failed to enhance biological yield compared to 30 kg P2O5 ha-1 whereas further addition of 50 kg P2O5 ha-1 found significant in enhancing biological yield of cowpea by 12.55 per cent compared to 30 kg P2O5 ha-1. This might be ascribed to enhancement both in growth and yield attributes. Adequate phosphorus levels boost vigorous root and shoot growth thus increased seed yield. The overall improvement in all these parameters owing to phosphorus nutrition appears to be due to its indispensable role in photosynthesis, pod development and grain filling in leguminous crops. It is accountable for nodulation in cowpea, thus higher nodulation resulted in higher nitrogen fixation and eventually the number of pods plant-1 and seed yield. These results substantiate findings of Singh *et al*. (2011) [5].

Table 1: Effect of weed management and phosphorus levels on weed dry matter, WCE, plant dry matter, LAI at harvest in cowpea crop

Treatments	Weed dry matter (kg ha^{-1})	Weed control efficiency	Plant dry matter at harvest (g plant^{-1})	LAI at harvest
Weed management				
Pendimethalin 1000 g PE *fb* HW	766	66.96	15.41	5.02
Imazethapyr + imazamox 45 g	1029	55.59	15.34	4.88
Pendimethalin 750 g PE *fb* imazethapyr + imazamox 33.75 g	535	76.90	16.26	5.23
One hoeing and weeding 15-20 DAS	1083	53.26	14.71	4.85
Weed free (up to 50 days)	314	86.46	16.70	5.67
Weedy check	2317	-	8.53	3.77
SEm±	22	-	0.29	0.05
CD (P= 0.05)	64	-	0.83	0.16
Phosphorus levels (P_2O_5 kg ha^{-1}				
30	963	58.43	13.05	4.61
40	1000	56.84	15.06	4.86
50	1060	54.25	15.37	5.24
SEm±	32	-	0.41	0.08
CD (P= 0.05)	91	-	1.18	0.22

Table 2: Effect of weed management and phosphorus levels on yield attributes and yield of cowpea

Treatments	No. of pods plant^{-1}	Seed yield plant^{-1} (g)	Yield (kg ha^{-1})		
			Seed yield	Haulm yield	Biological yield
Weed management					
Pendimethalin 1000 g PE *fb* HW	7.99	4.26	732	1988	2855
Imazethapyr + imazamox 45 g	7.36	3.93	674	1829	2600
Pendimethalin 750 g PE *fb* imazethapyr + imazamox 33.75 g	8.04	4.29	736	1999	2852
One hoeing and weeding 15-20 DAS	7.11	3.88	667	1809	2676
Weed free (up to 50 days)	8.40	4.48	770	2091	3038
Weedy check	3.37	1.88	322	865	1314
SEm±	0.15	0.09	15	42	51
CD (P= 0.05)	0.44	0.25	43	119	145
Phosphorus levels (P_2O_5 kg ha^{-1})					
30	6.38	3.41	585	1602	2390
40	7.22	3.85	661	1784	2588
50	7.53	4.11	705	1905	2690
SEm±	0.22	0.13	22	59	72
CD (P= 0.05)	0.34	0.39	62	170	207

4. Conclusion
Pre-emergence application of pendimethalin 750 g ha^{-1} accompanied by post-emergence application of imazethapyr + imazamox 33.75 g ha^{-1} at 15-20 DAS in cowpea recorded seed yield of 736 kg ha^{-1} comparable to weed free treatment (770 kg ha^{-1}) while application of 40 kg P_2O_5 ha^{-1} documented significantly higher seed yield (661 kg ha^{-1}) and further increasing dose of phosphorus by 10 kg failed to increase seed yield significantly.

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