International Journal of Research in Agricultural Sciences
Volume 1, Issue 3, ISSN (Online) : 2348 – 3997)

Nodulation, N and P Uptake as Influenced by Parthenium (*Parthenium Hysterophorus* L.) Densities in Common Bean (*Phaseolus Vulgaris* L.)

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Abstract - **A field experiment was carried out at Haramaya University during 2010 cropping season to determine the impact of parthenium on nodulation, N and P uptake by parthenium and common bean. There were nine treatments comprising 0, 3, 6, 9, 12, 15, 18, 21 and 24 parthenium plants m^{-2}grown with common bean. The experiment was laid out in Randomized Complete Block Design with three replications. The result showed that parthenium population significantly influenced nodulation in common bean and N and P uptake by parthenium and common bean. The significantly higher number of total and effective nodules was recorded in common bean grown in the absence of competition than in competition with parthenium. However, nodule dry weight was statistically at par between control, 3 and 6 parthenium plants/ m^2 and these treatments had significantly higher nodule dry weight/plant than the other parthenium densities. The N uptake by common bean grains and total aboveground plant was significantly higher in control than in competition with parthenium while no significant difference in N uptake was obtained between control and 3 plants/ m^2 of parthenium but both these treatments resulted in higher uptake than the other PARTHENIUM densities. The N uptake by parthenium increased with the increase in density up to 15 plants /m^2 and 12 and 15 parthenium plants/ m^{2}removed 85.93 and 91.42 kg N/ha which was significant over other densities. The common bean plant had higher uptake of N than parthenium up to 6 parthenium plants/m^2 whereas at higher densities it was lesser than parthenium. Like N, the P uptake by the crop was also adversely affected with increasing parthenium densities. But in contrast, P uptake by parthenium at all its densities was higher than common bean.**

Keywords – **Nitrogen, Nodules, Parthenium Densities, Phosphorus.**

I. Introduction

An invasive weed, parthenium (*Parthenium hysterophorus* L.), Asteraceae, was believed to be originated around Gulf of Mexico. In Ethiopia, it has become a serious weed both in arable and grazing land [1, 2). The plant is economically damaging because of its biological attributes, such as its high reproductive capacity, strong competitiveness, allelopathy and hazards to human and domestic animal health [3, 4].

It is thought that *P. hysterophorus* weed was introduced to Ethiopia through food aid. On the other hand, it was reported that *P. hysterophorus* was introduced to East Hararghe, Jijiga and Dire Dawa during Ethio-Somalian war of 1976-77 by army vehicles [5]. However, in the herbarium of Haramaya University, it has been recorded in 1968. It is just possible that after the weed was noticed around Dire Dawa in 1980's it has steadily spread throughout the country. Currently, *P. hysterophorus* has spread to almost all areas of the country [6].

In Ethiopia, [1] reported that many cereals, pulses and vegetable crops along with orchards were found infested by *P. hysterophorus*. The author also noted that infestation of *P. hysterophorus* in the crop fields varied across the country depending on the time of its introduction in to the area and the efforts made by the farmers to control the weed. It has become a major weed of the crops in the northern and eastern regions of Ethiopia. According to [7], *P. hysterophorus* reduced sorghum yield directly by competing for growth resources as well as by secretion of inhibiting inherent substances, which interfere in physiological growth and development of the crop. Also [8] reported that parthenium infestation has caused 86.5% yield losses in common bean crop in Eastern Ethiopia. In Eastern Ethiopia, it is reported to be the second most frequent weed (54%) after *Digitaria abyssinica* (63%) and, that sorghum grain yield was reduced from 40 to 97% depending on the year and the location [9, 10].

In Eastern Ethiopia, *P. hysterophorus* is of a great problem for livestock and crop production. The agricultural crops which are commonly produced in the area include mainly maize (*Zea mays* L.), sorghum (*Sorghum bicolor (*L.*)* Moench.), groundnut (*Arachis hypogaea* L.), common bean (*Phaseolus vulgaris* L.), faba bean (*Vicia faba* L.) and khat (*Catha edulis* Forsk), etc [11].

Common bean (*Phaseolus vulgaris* L.) is an annual herbaceous dicot that belongs to the Fabaceae family. It was originated in tropical America (Mexico, Guatemala, and Peru), but there are also evidences for its multiple domestication within Central America [12]. The crop occupies more than 90% of production areas sown under *Phaseolus* species [13].

The crop apart from serving as food and a source of income has a variety of other uses including their ability to harbor nitrogen fixing bacteria (*rhizobia*), serve as green manure crop to improve soil fertility and soil organic matter content. The crop is the most important food and export crop in Ethiopia and is a source of protein and cash for poor farmers [14]. In Ethiopia, the crop is usually grown by subsistence farmers as a sole and/or intercropped with either cereals (maize and sorghum) or tree crops (enset, coffee etc.).

Problems limiting common bean production are diseases, moisture stress, frost, drought, soil fertility, weeds, etc. Among weeds, *P. hysterophorus* is currently threatening the production of crop. But there is lack of scientific information that can explain impact of *P. hysterophorus* on common bean nodulation and N and P uptake.

Therefore, this study was initiated with two objective, primarily to:

1) Determine the impact of *P. hysterophorus* on nodulation of common bean and
2) To assess the effect of *P. hysterophorus* on nitrogen and phosphorus uptake by common bean.

II. Materials and Methods

2.1. Experimental site description

The experiment was conducted at Haramaya University Research Farm, Rarre, eastern Ethiopia during (June to October) 2010 main cropping season. The site is located at a latitude of 09^0 26'N, a longitude of 42^0 03'E and an altitude of 1980 m.a.s.l. The rainy season of the area is bimodal type with an average annual rainfall of 755.5 mm. The minimum and maximum temperatures during the growing season were 7.0^{o}C (October) and 28.5^{o}C (June), respectively. The soil of the experimental field was clay loam in texture with a pH, organic matter (%), total N (%), available P (ppm) and CEC of 7.89, 2.43, 1.036, 50.63 and 36.6, respectively.

2.2. Treatments and experimental design

Nine target densities of parthenium weed 0, 3, 6, 9, 12, 15, 18, 21 and 24 m^{-2} were established by thinning the naturally occurred parthenium weed density. These densities were chosen based on a survey of density of parthenium weed in crop fields in eastern Ethiopia [5]. After the required number was maintained, the late emerged parthenium weeds were removed manually. Also hand weeding was done frequently to remove all other weed species.

A randomized complete block design with three replications was used. The plot size was 14 m^2 (10 rows of 0.4 m apart and 3.5 m long) and the central 6 rows of 6.96 m^2 area were harvested. Each block and plots within blocks were spaced 1m and 0.5m apart, respectively. The outermost one row from each side and three plants from each end of rows served as border and there after one row (i.e. second) from each side of the plot were used for destructive sampling. Common bean variety "Chercher" (STTT-165-96) released by Haramaya University in 2006 was used in the experiment. This variety adapts the altitude range of 1300-1900 m.a.s.l. and rainfall of 1000-1300 mm [15]. It is navy-white in color, determinate bush type, flowers and matures in 50-58 and 93-103 days, respectively. Healthy seeds (completely filled and not attacked by insects) were planted manually at recommended spacing (40 cm x 10 cm) in the first week of July 2010 to the recommended density of 250, 000 plants ha^{-1}. At the time of planting, all plots received a uniform basal application of 18% N, and 20% P as Diammonium Phosphate (DAP) at the rate of 100 kg /ha. Plot wise harvesting of **c**ommon bean crop was done on the second week of October 2010 when the pods and leaves of the crop turned yellow and dry. Harvesting and threshing of common bean was done by hand and the grain yield was adjusted to 10% moisture content.

For common bean crop, days to flowering and physiological maturity were recorded at 50% flowering of plants and when pods of 90% of the plants were changed to yellow, respectively. Data on nodules was collected at flowering stage. Samples for nodulation were taken by digging out the roots of six randomly taken plants from destructive sampling rows in each plot. A spade was used to collect an undisturbed soil core containing entire root system. The undisturbed soil samples were wrapped in plastic and soil clods were carefully removed leaving the nodule intact on the roots. The remaining soil on the root was washed with gently running tap water on sieve to clean root nodules. Nodules from root crown region (tap root) and lateral roots were carefully removed and counted, and the mean value of six plants per plot was recorded as number of nodules plant^{-1}. Then the nodules which were pink in color when broken were identified as effective nodules and the average was recorded as the effective nodules plant^{-1}. The collected nodules were dried at 65 ^{0}C in an oven to a constant weight to determine nodule dry weight. Samples of grain, straw and *P. hysterophorus* weed (above ground biomass) which were randomly taken from each treatment were oven dried at 65^{o}C till a constant weight and ground to pass through 2 mm mesh sieve. Tissue analysis for nitrogen (N) and phosphorus (P) uptake was carried out in duplicates at Haramaya University Central Soil Laboratory. Nitrogen in the plant tissue was determined using micro-Kjeldhal method by digesting with concentrated sulfuric acid as described by [16]. Phosphorus content was determined calorimetrically by vanado-molybdate method. Total N or P uptake by whole crop was calculated by summing up the straw and grain uptake of N or P which was computed by multiplying N and P concentration of straw and grain by corresponding dry weight. In *P. hysterophorus* it was worked out on the basis of concentration of nutrients and shoot dry matter.

2.3. Statistical analysis

Collected data were subjected to the analysis of variance (ANOVA) with the appropriate design as per [17] using SAS version 9.0 computer software program (SAS, 2002). Mean separation was performed for significant treatment means using Least Significant Difference (LSD) at 5% level of probability.

III. Results and Discussion

3.1 Effect of parthenium densities on common bean growth

There was significant difference ($p< 0.05$) in days to 50% flowering among treatments (Table 1). Days to 50% flowering ranged from 54.0 to 57.7 days. Flowering (54.0 days) was significantly enhanced in the absence of inter-specific competition and parthenium density of 3 plants m^{-2}. This showed that the competitive effects of parthenium at this density had no significant influence on flowering of common bean. The significant delay in flowering by 1.7 to

International Journal of Research in Agricultural Sciences
Volume 1, Issue 3, ISSN (Online) : 2348 – 3997)

3.7 days at higher densities i.e. 9 to 24 plants m^{-2} might be due to shading effect of fast growing parthenium densities on limited space. It was also observed that at very high densities, the parthenium canopy virtually covered common bean plants completely, thereby obstructing the penetration of solar radiation, which in part, might have contributed to delayed growth and development of common bean (Table 1). Similarly, [19] reported delayed flowering in common bean with increasing shade level. Further, parthenium is known to have negative weed-crop interference, i.e. competition for (nutrients, moisture, light and space) as well as allelopathic effect that inhibits the growth of crops. This result is in harmony with [20] who reported delayed flowering of finger millet due to weed interference. Also [21] reported that the prolonged period of weed interference resulted in late flowering in sesame crop.

In the absence of competition from parthenium, common bean had significantly higher number of total and effective nodules $plant^{-1}$ than competition under the influence of different densities of the weed. This is in agreement with the finding of [22] who reported the inhibitory effect of root and leaf extracts of parthenium on growth of N-fixing bacteria. The leaf and root leachates: parthenin, anisic acid, vanillic acid and fumaric acid inhibited nitrate production. Further, densities of 21 and 24 plants m^{-2} and 18, 21 and 24 plants m^{-2} exhibited a significant reduction in total and effective nodules $plant^{-1}$ respectively as compared to other densities.

At higher parthenium densities, it may be the consequences of more severe competition that results in reduction in the total and effective nodules plant $^{-1}$ and allelophatic effect of parthenium weed on common bean during nodule formation. This is in agreement with [23 and 24] who found inhibited growth and nodulation in legumes due to parthenium. Also the increased population might have resulted in poor root growth thus the reduced sites for nodule formation which reduced the activity of N_2 fixing microorganisms. On the other hand, [25] reported that the leachates from stem and leaf of parthenium weed reduce growth rate in the nitrifying bacteria. Common bean nodule weight was also significantly influenced due to competition from parthenium densities. Phenolics produced by decomposing rice residues inhibited the growth of N fixing bacteria reduced nodule number thus N fixing bacteria in soybean [27]. Similarly [28] reported that nodule number and weight could be as a result of legumes genetic character to have up to a certain number, if favored by environmental factors and management practices.

Table 1: Effect of parthenium densities on days to flowering, total and effective nodule number and nodule dry weight.

Parthenium density m^{-2}	Days to 50% Flowering	Number of nodules $plant^{-1}$	Number of effective nodules $plant^{-1}$	Nodule weight (mg $plant^{-1}$)
0	54.0	29.7	24.1	281.7
3	54.0	27.0	21.9	265.3
6	55.7	28.0	19.8	271.0
9	55.7	22.0	17.8	185.7
12	56.7	12.6	6.2	174.7
15	57.7	8.5	4.9	145.0
18	57.3	9.0	2.3	151.7
21	57.0	4.2	1.0	45.7
24	57.7	3.9	0.7	44.7
LSD (5%)	**1.49**	**1.4**	**1.9**	**35.5**
CV (%)	**1.5**	**4.9**	**10.1**	**11.8**

LSD =Least significant difference at alpha 5% level, CV (%) = Coefficient of variation,
Means followed by the same letter(s) in a column are not significantly ($p < 0.05$) different from each other

3.2 Effect of parthenium densities on N and P uptake by common bean

The increased population significantly ($p<0.05$) influenced N uptake by parthenium weed. The maximum N uptake (91.42 kg ha^{-1}) was recorded with 15 plants, followed by 12 plants m^{-2}. The N uptake by parthenium at both these densities though did not differ significantly but resulted in a significant increase over all other densities. Also, the N uptake by parthenium decreased significantly with the successive decrease in density below 12 plants m^{-2} though no such difference was noticed between 18 to 24 plant m^{-2} indicating increased intra-specific competition for resources at higher densities.

The decreased N uptake by parthenium compared at 12 and 15 plants m^{-2} at higher densities (18 to 24 parthenium plants m^{-2}) was also due to lower dry matter biomass m^{-2}, despite similar dry matter biomass in case of 15 plants m^{-2} the higher concentration of N in plant tissue might have resulted in higher N uptake. The N uptake by grain, straw and crop was also significantly affected by parthenium population. This ascertains the superiority of parthenium in the uptake and utilization of nitrogen as compared to crop. The highest N uptake by grain, straw and crop was recorded from control treatment which was 28.45, 66.82 and 95.27 kg ha^{-1}, respectively. The N uptake by grain, straw and total (grain+ straw) decreased with increasing parthenium population. However, at 18 to 24 plants m^{-2} it was significantly lower than the other densities probably due to significant reduction in yield at these densities hence, reduced uptake. The significantly low N uptake by the crop at 18 to 24 plants m^{-2} as compared to other densities signify a very high impact of parthenium on limited growth resources. Total N content of plant is an indication of the plant's capacity to accumulate N [25]. A perusal of data (Table 2) further revealed that the overall (crop+ parthenium) total uptake of N varied between 112.12 and 125.75 kg ha^{-1} in treatments.

Table 2: Effect of parthenium densities on N and P uptake by common bean grain, straw total plant and parthenium

	N uptake (kg ha^{-1})				P uptake (kg ha^{-1})			
Parthenium density m^{-2}	Grain	Straw	Total	Parthenium	Grain	Straw	Total plant	Parthenium
0	28.45	66.82	95.27	-	13.61	12.76	26.37	-
3	23.06	65.33	88.39	37.36	10.85	11.92	22.77	24.95
6	19.08	52.74	71.82	52.21	7.39	8.33	15.72	33.08
9	14.90	35.93	50.83	61.29	5.88	6.63	12.51	34.78
12	14.50	24.19	38.69	85.93	5.35	4.78	10.13	43.88
15	6.89	20.89	27.78	91.42	1.77	4.65	6.43	47.98
18	3.02	13.77	16.79	73.90	0.90	2.25	3.15	43.51
21	2.07	9.80	11.87	70.94	0.78	1.64	2.42	40.49
24	2.02	9.52	11.53	72.69	0.74	1.52	2.26	40.62
LSD (5%)	**2.593**	**5.133**	**6.063**	**6.949**	**2.339**	**1.243**	**1.976**	**2.675**
CV (%)	**11.83**	**8.93**	**7.63**	**6.62**	**25.72**	**11.86**	**10.09**	**4.49**

LSD=Least significant difference at alpha 5% level, CV (%) = Coefficient of variation,
Means followed by the same letter(s) in a column are not significantly ($p < 0.05$) different from each other

A perusal of data (Table 2) further revealed that the overall (crop+ parthenium) total uptake of N varied between 112.12 and 125.75 kg ha^{-1} in treatments comprising a density of 3 to 15 parthenium plants m^{-2} that was higher than the common bean alone (95.27 kg N ha^{-1}) which showed that the deeper roots of parthenium might have mined the nutrient from deeper soil layers. However, at higher densities (18 to 24 plants m^{-2}) and despite more severe competition offered by parthenium, the overall N uptake was lower than that of common bean grown in the absence of competition from parthenium. This might be due to intra-specific competition, as N uptake at these densities by parthenium was significantly lower than at 12 and 15 plants m^{-2} (Table 2).

Like N uptake, the increased population of parthenium weed also significantly ($p< 0.05$) affected P uptake by parthenium. The significantly low (24.95 kg ha^{-1}) P uptake was obtained when parthenium density was 3 plants m^{-2} compared to other densities. This might partially be due to better competitive ability of common bean against parthenium at this density. The P uptake by parthenium increased with the increase in parthenium density up to 15 plants m^{-2}, where it was significantly high over other densities (Table 2). This might be due to the intra-specific competition that occurred within parthenium as the population increased beyond this density. In case of P uptake, also the trend was similar to N where the uptake was reduced with the increase in parthenium infestation level.

However, unlike N uptake, the difference in P uptake by grain and straw was narrower up to 12 parthenium plants m^{-2}. The maximum P uptake of the grain (13.61 kg ha^{-1}) was obtained from the control treatment. This was followed by the treatment which was infested by 3 parthenium plants m^{-2} (10.85 kg ha^{-1}). The total P uptake by the crop decreased significantly with successive increase in density up to 18 plants of parthenium m^{-2} beyond which weed density had no significant effect on P uptake.

IV. Conclusion

Parthenium has been receiving much attention because of its damage to crop and soil health in terms of fertility. Under field conditions, crops are infested with complex weed flora and varied inter-specific competition, and farmers resort to some control measures; however, in this experiment *P. hysterophorus* was allowed to grow uninterrupted to determine the extent competition and damage, it could cause to common bean nodulation and N and P uptake. From this finding it can be concluded that in the areas where parthenium weed infestation is even 3 plants m^{-2}, management strategy has to be formulated to curb interference of parthenium for nodulation of common bean and N and P uptake. The crop can smother parthenium weed, thus using this crop in such areas as an intercrop and/ or in rotation with cereals may help to curb the potential impact of parthenium on crop production. However, still there is need to verify the results, in addition to study the competition effect with varying common bean inter- and intra-row spacing with lower weed population.

Acknowledgement

Financial support from Ministry of Education (MOE), Ethiopia, which was used to cover the expenses incurred, is greatly acknowledged.

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He has published one journal in Ethiopian Journal of Weed Management entitled "Competitive effect parthenium weed on yield and yield components of common." He has 6 months experience as plant sciences expert and 1 year teaching experience as University instructor at Mizan-Tepi University. Currently, he is a second year PhD student in Agronomy field at Haramaya University, Ethiopia and doing a research entitled 'Integrated Nutrient Management for Food Barley (*Hordeum vulgare* L.) Production in Kaffa Zone, South-Western Ethiopia' sponsored by Mizan-Tepi University, Ethiopia.

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