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IRRIGATED CHICKPEA'S SYMBIOTIC EFFICIENCY, GROWTH AND PRODUCTIVITY AS AFFECTED BY FOLIAR APPLICATION OF UREA

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Abstract- Nitrogen (N) nourishment in legumes is essential for achieving greater productivity as biological nitrogen fixation by nodules in these crops ceases towards maturity. This study was conducted to elucidate the response of chickpea to foliar application of N through urea at different growth stages under irrigated conditions of Punjab, India. Plant nodule numbers, nodule dry weight and leghaemoglobin content increased significantly with foliar spray of 2% urea at different growth stages of crop over unsprayed control. Chlorophyll kinetics and highest quantum efficiency of Photosystem II was recorded with foliar spray of 2% urea at pod initiation stage. Yield attributes such as pods/plant improved significantly with 2% foliar spray of urea at different growth stages over no spray treatment. Foliar spray of urea (2%) at pod initiation stage recorded significantly higher grain yield thereby recorded highest gross returns, net returns and benefit cost ratio over unsprayed control.

Keywords- Chickpea, Chlorophyll kinetics, Leghaemoglobin, Nodulation, Productivity, Urea spray

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Introduction

Pulses play very important role in providing over all prosperity to small and marginal framers through nutritional security by meeting their dietary protein requirements. Apart from it, legumes also significantly contribute to agricultural sustainability through nitrogen fixation and as a rotation crop allowing diversification of agricultural production system. In India, chickpea (*Cicer arietinum* L.) is major winter season pulse crop and contributes about 50% of the total pulses production [1] and hence contributes significantly in augmenting the pulse production of the nation. Chickpea seed yield production is affected by many biotic, abiotic and agronomic factors. Among agronomic factors, nitrogen application at various growth stages of chickpea is an important criterion for achieving higher productivity of this important legume. In pulse crops, nodule degeneration generally occurs in the post flowering stage [2]. Active nodulation and nitrogen fixation ability of symbiotic *rhizobium* are terminated partially or completely due to excessive diversion of carbon or photosynthates towards actively growing pods. Consequently nodules face scarcity of photo-assimilates resulting in dysfunction or shrinkage of leading to poor performance of plant. Nitrogen fixation gets reduced due to degeneration of nodules coupled with low nitrogenase activity [3] which affects nitrogen nourishment of crop at the later stages resulting loss of crop productivity. Reducing levels of nitrogen in the leaves during the pod filling period due to translocation of this element from leaves to the developing seeds coupled with poor nutrient uptake from the soil and reduced symbiotic nitrogen fixation may result low photosynthesis leading to the acceleration of leaf senescence in plants [4]. The chlorophyll content and PS-II efficiency, major physiological traits, are decreased at senescence stage and these can be improved when plants are fertilized with nitrate at the initiation of leaf senescence [5]. Urea is the most commonly preferred N-fertilizer for foliar application because of its easy solubility in water, low cost, easy leaf penetration and easily hydrolysable in the cytosol [6]. Foliar application of N through urea in reproductive phase proved very effective in increasing the productivity of rainfed chickpea as it meets the requirement of nitrogen for grain formation [7,8]. Urea spray helps in sustaining greenness of leaves for longer period which helps in improving productivity due to better photosynthesis in plants. Foliar urea spray also improves the storage of N compounds like amino acids and proteins in plants [9,10] thus, directly affects N metabolism under stressful conditions Also, plants fertilized with N had better tolerance to photo-oxidative damage during heat stress and had higher photosynthetic capacity resulting in enhanced yield of legumes [11]. These results indicate the potential to increase yields of chickpea by application of foliar nitrogen near flowering under irrigated conditions also [12].

The cultivation of chickpea is mainly done on marginal lands and grain yield of chickpea under such condition is lower than the potential yield. Therefore, adoption of methods/techniques which results improvement in grain yield will have positive effects on social and economic status of chickpea growers. The present study was, therefore, executed to reveal the influences of foliar application of N through urea at different stages on chickpea productivity under irrigated conditions.

Materials and Methods

Field experiments were performed during the winter seasons of 2007-08 and 2008-09 at the experimental farm of the Punjab Agricultural University, Ludhiana, Punjab, India which is situated at 30° 56' N, 72° 52' E; 247 m above sea level. The top soil profile (0-15 cm) was neutral in pH (7.5, 1 : 2 soil : water ratio) having electrical conductivity of 0.12 dS/m, was low in N (132.0 kg/ha) and organic carbon (0.30%), medium in P (12.5 kg/ha) and K (240 kg/ha). The crop received rainfall of 87.5 and 80.4 mm during the year 2007-08 and 2008-09, respectively. The mean weekly maximum temperatures ranged from 14.8 to 35.4ºC and 16.5 to 38.1ºC during 2007-08 and 2008-09, respectively, whereas, corresponding figures for the mean weekly minimum temperature varied from 0.9 to 18.7ºC and 5.6 to 19.5ºC during 2007-08 and 2008-09, respectively. Six treatments *viz.*, no foliar spray (Control), 2% urea spray at vegetative stage [60 days after sowing (DAS)], 2% urea spray at flower initiation stage (85 DAS), 2% urea spray at pod initiation stage (105 DAS), 2% urea spray at vegetative stage + flower initiation stage and 2% urea spray at flower initiation stage + pod initiation stage were evaluated in a randomized block design (RBD) with four replications. Nutrients were applied @ 15 kg N + 20 kg P_2O_5/ha as basal dose in all the treatments at sowing time. N and P were applied through urea (46% N) and single superphosphate (16% P_2O_5), respectively. The 2% solution of urea for foliar application was prepared by dissolving 200 g urea per 10 litres of water and was sprayed immediately. A total of 350 litres of urea solution was used per hectare. Water was applied @ 75 mm as pre-sowing irrigation and soil was cultivated by disc plough, followed by one cultivation and planking at field capacity to prepare a fine seed bed. The chickpea cultivar 'GPF 2' used for sowing on November 14, 2007 and November 12, 2008 in 30 cm rows apart with a seed rate of 45 kg ha^{-1}. The seeds were inoculated with *Rhizobium* before sowing. For meeting the water requirements of the crop, irrigations were applied at branching and pod initiation stage. Weeds were removed by hand weeding at 30 and 60 days after sowing (DAS). Thiodan 35 EC (endosulphan) @ 2.5 L ha^{-1} was applied to control pod borer (*Helicoverpa armigera* Hub.). The crop was harvested manually during the third week of April in both the years.

Data on number of nodules with respect to native *rhizobia* and nodule dry weight were recorded at flower initiation stage (85 DAS) and at during pod formation stage (105 DAS). Five plants were uprooted from each plot, their roots were washed, and then nodules were separated from them and counted. Nodules dry weight was recorded after drying them till constant weight was achieved at 65ºC in an oven. The leghaemoglobin content was analyzed by the method given by [13] at complete podding stage. "Chlorophyll Fluorometer OS 30p" was used to measure chlorophyll kinetics at complete podding stage by measuring ratio of Fv/Fm which represents the efficiency of Photosystem-II (PS-II). The value of Fv/Fm is an index which is positively correlated with plants' ability to maintain higher photosynthetic efficiency. At maturity, data on growth and yield attributes like plant height, primary and secondary branches and pods per plants were recorded from five randomly selected plants. Ten pods were randomly selected to count the seeds/pod. Biological yield (aboveground total dry matter of the crop at the time of harvest) and grain yield were recorded on a whole plot basis. For recording data on 100-seed weight, 100 seeds were randomly selected after threshing. Economic returns were calculated by taking the sale price of chickpea as ₹ 3600 per quintal.

Net returns (₹/hectare) were calculated as follows:

Net income = Gross returns - cost of cultivation including the cost of individual treatments

Benefit : cost ratio was determined after dividing net income with the cost of cultivation

All the data were subject to analysis of variance (ANOVA) as per the standard procedure. The data presented is averaged over two years and treatment means were compared by critical difference (CD) at $P \le 0.05$.

Results and Discussion

Symbiotic Parameters

There was significant improvement in nodule number and nodule dry weight with 2% urea spray at different growth stages over no urea spray [Table-1]. Highest nodule number and nodule dry weight was recorded with 2% urea spray at vegetative + flower initiation stages and was statistically at par with 2% urea spray at vegetative stage but significantly superior to other treatments. Nitrogen requirement in legumes during reproductive stage is far higher which was met from foliar application of urea in our study resulting in higher nodule number and nodule dry weight. However, in control treatment, this N requirement might have been met at the expense of nodule growth. Similarly, [14] also observed that foliar application of N through urea during different growth stages increased the nodule mass and nitrogenase activity in fababean (*Vicia faba*). Leghaemoglobin (Lb) plays crucial role in nitrogen fixation of by nodules in legume crops. Leghaemoglobin content in nodules was also enhanced significantly with 2% urea spray at different growth stages over no spray. Foliar spray of 2% urea at vegetative + flower initiation rerecorded highest leghaemoglobin content and was statistically at par with 2% urea spray at vegetative stage alone but significantly higher than all other treatments. These results are supported by the findings of [15] who reported that increased availability of larger number of *rhizobia* around the root zone might have improved nodulation and enhanced leghaemoglobin content in chickpea.

Chlorophyll Kinetics

Foliar application of N through urea at different growth stages resulted in significant improvement in quantum efficiency of PS II of chickpea as depicted through chlorophyll kinetics recorded 10 days after pod initiation stage [Table-1]. Foliar application of 2% urea at pod initiation stage recorded maximum quantum efficiency of PS II which was statistically at par with 2% urea spray at all other growth stages but was significantly higher than no spray. Nitrogen is component of chlorophyll and therefore is essential for photosynthesis. Foliar feeding of urea resulted in more availability of nitrogen which could have increased the chlorophyll and carotenoid content, chlorophyll a : chlorophyll b, which improved PS-II activity and thereby resulted in photosynthetic efficiency per unit leaf area [16]. Similar findings are observed in chickpea by [17].

Growth & Yield Parameters and Yield

The plant height, primary and secondary branches and 100-seed weight of chickpea did not differ significantly due to various treatments of urea spray [Table-2]. Foliar application of urea brought significant improvement in number of pods/plant and 2% urea spray at vegetative stage + flower initiation stage produced highest pods per plant which was significantly higher than 2% urea spray at vegetative stage alone and unsprayed control. Highest seeds/pod was obtained in 2% urea spray at flower initiation stage + pod initiation stage which were significantly higher than all other treatments.

Biological yield was also significantly influenced by urea spray at different growth stages [Table-3]. The application of 2% urea spray at vegetative stage + flower initiation stage recorded maximum biological yield which was statistically at par with all other treatments except unsprayed control. Foliar supplementation of N at different growth stages resulted in significant improvement in grain yield. The maximum grain yield was obtained with 2% urea spray at pod initiation stage which was statistically at par with all other treatments except unsprayed control. In this study, the increased grain yield with foliar application of 2% urea at different growth stages is in line with the earlier findings of [18] who had reported that effective symbiosis resulted in more nitrogen fixing sites which ultimately enhanced nutrient uptake and yield in chickpea. Moreover, better photosynthetic efficiency with foliar application of 2% urea at different growth stages [Table-1] might have resulted in better accumulation and translocation of photosynthates towards the sink which is evident from significantly higher number of pods/plant [Table-2] thereby resulting in higher chickpea grain yield.

Table 1- Symbiotic parameters and maximum quantum efficiency of photosystem (PS II) as influenced by urea spray at different growth stages in chickpea recorded at complete podding stage (two years mean)

Treatment	Number of nodules/plant	Dry weight of nodules/plant (mg)	Leghaemoglobin content (mg/g fresh weight of nodules)	Chlorophyll kinetics (Fv/Fm)
No foliar spray (control)	25.8	105.5	4.48	0.704
2% urea spray at vegetative stage	38.2	136.0	5.04	0.734
2% urea spray at flower initiation stage	32.8	122.0	4.78	0.739
2% urea spray at pod initiation stage	32.3	124.0	4.70	0.751
2% urea spray at vegetative + flower initiation	40.0	137.3	5.25	0.744
2% urea spray at flower initiation and pod initiation	33.7	128.9	4.84	0.742
SE+	1.9	4.7	0.1	0.006
CD at 5%	4.9	11.3	0.22	0.018

Table 2- Growth and yield attributes of chickpea as influenced by urea spray at different growth stages (two years mean)

Treatment	Plant height (cm)	Primary branches/plant	Secondary branches/plant	Pods/plant	Seeds/pod	100-seed weight (g)
No foliar spray (control)	55.5	4.30	5.35	25.9	1.67	14.0
2% urea spray at vegetative stage	56.2	4.57	5.79	30.1	1.64	14.3
2% urea spray at flower initiation stage	57.3	4.47	5.54	31.7	1.67	14.1
2% urea spray at pod initiation stage	57.4	4.50	5.68	33.5	1.73	14.2
2% urea spray at vegetative + flower initiation	57.9	4.17	5.94	34.8	1.74	14.3
2% urea spray at flower initiation and pod initiation	56.5	4.24	5.92	33.7	1.87	14.1
SE+	1.4	0.2	0.27	1.6	0.04	0.2
CD at 5%	NS	NS	NS	4.1	0.1	NS

Table 3- Yield and economics of chickpea as influenced by urea spray at different growth stages (two years mean)

Treatment	Biological yield (kg/ha)	Grain yield (kg/ha)	Gross returns (x 10^3 ₹/ha)	Net returns (x 10^3 ₹/ha)	B:C ratio
No foliar spray (control)	5444	2082	74.9	44.9	1.50
2% urea spray at vegetative stage	5648	2358	84.9	54.6	1.80
2% urea spray at flower initiation stage	5833	2382	85.7	55.4	1.83
2% urea spray at pod initiation stage	5908	2487	89.5	59.2	1.96
2% urea spray at vegetative + flower initiation	5963	2461	88.6	58.0	1.90
2% urea spray at flower initiation and pod initiation	5852	2396	86.3	55.7	1.82
SE+	128	82	2	1.9	0.08
CD at 5%	325	202	4.8	4.7	0.18

Economics

Foliar application of 2% urea at different growth stages resulted in significantly higher returns as compared to unsprayed control [Table -3]. Highest economic returns, net returns and B:C ratio was recorded with 2% urea spray at pod initiation stage closely followed by 2% urea spray at vegetative stage + flower initiation stage and were statistically at par with 2% urea spray at vegetative stage, 2% urea spray at flower initiation stage and 2% urea spray at flower initiation + pod initiation stage. In addition to basal application of RDF, foliar spray of 2% urea at different growth stages resulted in higher yields and thereby recorded higher gross returns, net returns and B:C ratio.

Conclusion

From this study, it can be summarized that foliar application of 2% urea at early podding stage or at vegetative + flower initiation stage is appropriate for enhancing the seed yield in irrigated chickpea as nitrogen from urea gets quickly assimilated in the leaves, build up proper N status, restore photosynthesis and increases grain yield.

Conflicts of Interest: None declared.

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