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IMPACT OF FOLIAR SPRAY OF NPK AND GIBBERELLIC ACID ON QUALITY AND NUTRIENT UPTAKE OF CHICKPEA BASED INTERCROPPING SYSTEM

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ABSTRACT

An agronomic investigation was conducted during *rabi* season of 2019-20 and 2020-21 at Birsa Agricultural University, Ranchi. The experiment was laid out in split plot design with 3 replications. The treatments were comprised of 9 main plots *viz.*, sole chickpea, sole wheat, sole linseed, sole safflower, sole mustard, chickpea + wheat (6:3), chickpea + linseed (6:2), chickpea + safflower (6:2), chickpea + mustard (6:2) and 3 sub-plots *viz.*, foliar spray of water (control), 1% NPK (19:19:19) and GA_3 (100 ppm). Results revealed that maximum grain yield (1273 kg/ha), protein and oil content (%) and total nitrogen uptake (93.56 kg/ha) were recorded with chickpea + mustard (6:2) and closly followed by chickpea + linseed. While total phosphorus uptake (23.25 kg/ha) was maximum in sole wheat and total potassium uptake was maximum in sole mustard (67.36 kg/ha). With regards to different foliar spray treatment, the maximum value for protein content and total phosphorus uptake by component crops was obtained under foliar spray of 1% NPK (19:19:19) at 45 days after sowing, whereas, grain yield, oil content and total nitrogen as well as potassium uptake were found maximum under foliar spray of GA_3 (100 ppm) at 45 days after sowing during both the years of experimentation.

KEY WORDS: Chickpea, Foliar spray, Gibberellic Acid, Intercropping, NPK (19:19:19)

INTRODUCTION

Chickpea (*Cicer arietinum* L.) is an important legume crop that provides protein, dietary fibre, minerals and vitamins to human nutrition. It is also a valuable source of nitrogen for the soil due to its ability to fix atmospheric nitrogen through symbiotic association with rhizobia bacteria. India ranks first in pulse production (27.81 million metric tonnes) and area (31 million ha) in which chickpea has recorded a production of 13.75 million tonnes in an area of 10.91 million ha with the productivity 2600 kg/ha (Anonymous, 2023). Chickpea constitutes 38% area and 48% production of pulses in India. In Jharkhand, area, production and yield of chickpea were 2.65 lakh ha, 3.34 lakh tonnes, and 1257 kg/ha (Anonymous, 2022). Chickpea is grown in diverse agro-ecological zones, ranging from semi-arid to sub-humid regions and is often cultivated under rainfed conditions with low input use. Intercropping is one of the promising practices that can improve the resource use efficiency, yield stability, and economic returns of chickpea production. Intercropping can provide several benefits, such as reducing pest and disease incidence, suppressing weed growth, improving soil health, diversifying income sources, and reducing risk of crop failure. Intercropping offers an opportunity for efficient utilization of light, water, land and other inputs. As compared to sequential cropping and relay cropping, the practice of intercropping is known to increase the total productivity, because, the crops are able to utilize different resources at a time (Willey, 1979).

Intercropping with specific crop species is more productive, profitable and secured than sole cropping. However, the choice of intercrop species, the spatial arrangement, and the management practices should be carefully considered to optimize the complementarity and compatibility between the component crops and to avoid negative effects on chickpea growth and yield. Intercropping of pulses with wheat, mustard, cotton and sugarcane etc. is commonly practiced in some parts of India (Sharma *et al*., 1993). Intercropping of pulses in combination with cereals and oilseeds not only fetches remunerative prices but also avert the risk of crop failures, besides it acts as an assurance against the varied influences of weather. Plant growth regulators like GA_3 have the potential to increase agricultural production by influencing various physiological processes in crops. Chickpea cultivation faces challenges related to flower and pod shedding, low seed set and poor yield. The use of plant growth regulators as foliar spray can improve yield and quality in chickpea. Foliar application of NPK fertilizer can manipulate chickpea growth, increasing yield and yield components. It is a temporary solution but has shown positive results in many crops. Foliar application of NPK can stimulate leaf growth, increase protein and chlorophyll content, improve root biomass, and enhance plant resilience.

Therefore, the main objective of this investigation is to study the effect of foliar application of NPK and GA_3 on the productivity and quality of chickpea and its intercrops under different intercropping systems.

MATERIALS AND METHODS

A field experiment was carried out during *rabi* season of 2019-20 and 2020-21 at Birsa Agricultural University, Ranchi. The maximum temperature varied between 19.9° to 37.0°C during 2019-20 and 20.3 to 36.8 °C during 2020-21, while minimum temperature ranged between 3.8 to 22.9 °C during 2019-20 and 3.6 to 19.4 °C during 2020-21. During experimentation, the crops received a total rainfall of 134.7 mm in 2019-20 and 32.4 mm in 2020-21 (Fig. 1 & 2). The soil of the experimental field was sandy loam in texture. The soil was slightly acidic (5.6 pH) during both years on mean basis. It had medium available nitrogen (221.2 kg/ha), high available phosphorus (23.5 kg/ha) and medium available potassium (158.4 kg/ha) content during both the years as well as on mean basis. The research consists of nine treatments in main plots [sole chickpea, sole wheat, sole linseed, sole safflower, sole mustard, chickpea + wheat (6:3), chickpea + linseed (6:2), chickpea + safflower (6:2) and chickpea + mustard (6:2)] and 3 treatments in sub-plots [foliar spray water, 1% NPK (19:19:19) and 100 ppm GA_3] with a total of 27 different treatment combinations. The varieties used in the experiment were Birsa chana 3, K 1317, Divya, A 1, NRCBH-101 for chickpea, wheat, linseed, safflower and mustard, respectively. The experimental fields were ploughed twice with harrow followed by planking to get fine tilth. Full dose of nitrogen (Urea and DAP), phosphorus (DAP), potash (MOP) and lime were applied as basal in the line before sowing of chickpea. In case of mustard, linseed, safflower and wheat, half of nitrogen as well as full dose of phosphorus, potash, sulphur (phospho-gypsum) and lime were applied on the line at the time of sowing. Rest of nitrogen was applied in two equal splits at 30 DAS and 55 DAS as top dressing. Stock solution of GA_3 (1000 ppm) was prepared and then GA_3 @100 ppm made from stock solution while concentration of NPK @1% was maintained with water, which was sprayed on the crops at 45 days after sowing. All the crops were sown during last week of November and harvesting of chickpea and wheat were done during the third week of March, mustard was harvested during the second week of March while, linseed and safflower were harvested during the last week of March. In the net plot area were harvested separately from gross plot and kept for air-drying. Later on total biomass yield from each net plot was recorded, after threshing grains were separated, cleaned and weighed. Straw or stover yield per net plot was worked out by subtracting respective total grain weight from the total biomass. Later the grain yield per plot computed to hectare basis and expressed as kg/ha. The protein content (%) was calculated by multiplying the nitrogen content of grain by the standard factor 6.25 (Crompton and Harvois, 1969). Oil content of oven dried seeds of mustard, linseed and safflower was estimated by Nuclear Magnetic Resonance (NMR) method against a standard reference sample (AOAC, 1975). Uptake of nutrients (kg/ha) was calculated by using the following formulation:

NPK uptake (kg/ha) = [Concentration of NPK in grain or straw (%) × Grain or straw yield (kg/ha)]/ 100

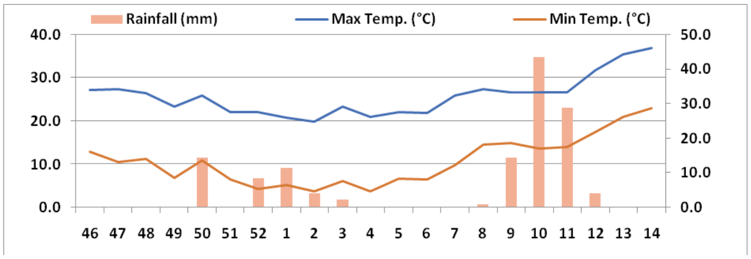

Fig. 1. Weakly weather data during 2019-20

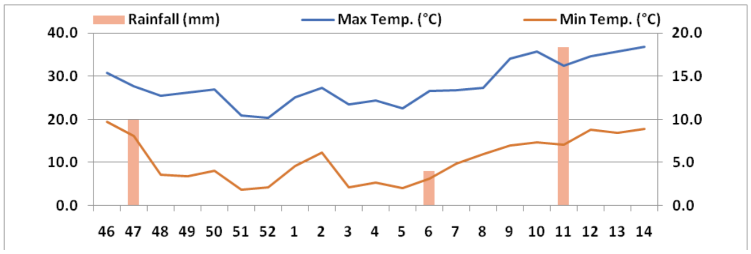

Fig. 2. Weakly weather data during 2020-21

RESULTS AND DISCUSSION

Effect of foliar spray on productivity of chickpea based intercropping

Data revealed (Table 1) that higher grain yield of chickpea per unit area was produced under chickpea + mustard (6:2) than that of chickpea + linseed (6:2), chickpea + safflower (6:2), and chickpea + wheat (6:3) as compared to sole chickpea while lowest grain yield of chickpea was noted under chickpea + wheat (6:3). This favourable increase in grain yield due to intercropping could be probably because of increase in the land use efficiency, resource utilization, and crop productivity over sole cropping by creating a complementary or facilitative interaction between the crops. Similar results were reported by Singh and Aulakh, 2017.

With respect to foliar spray of GA_3 (100ppm) and 1% NPK, maximum grain yields of chickpea, mustard, linseed, safflower and wheat were recorded with spraying of GA_3 (100 ppm) followed by 1% NPK, while minimum grain yield was registered under water spray (control). This variation occurred because GA_3 increases the dry matter in crops by promoting RNA synthesis and accelerated enzyme activity responsible for biomass accumulation. Spraying of plant growth regulators, increase water and nutrient might be the reason for accelerated photosynthetic rate, thereby increasing the supply of nutrients, resulted in increased grain yield.

Table 1. Effect of foliar spray of NPK and GA_3 on grain yield of chickpea based intercropping system. (Mean of 2019-20 and 2020-21)

Treatment	Grain yield (kg/ha)						Mean
	S1 (water spray)		S2 (1% NPK 19:19:19)		S3 (GA_3 100ppm)		
	CP	W/LS/SF/M	CP	W/LS/SF/M	CP	W/LS/SF/M	
Sole CP	1414	-	1526	-	1592	-	1511
Sole W	-	3250	-	3421	-	3508	3393
Sole LS	-	1416	-	1520	-	1580	1505
Sole SF	-	1048	-	1136	-	1185	1123
Sole M	-	1438	-	1559	-	1623	1540
CP+W	1072	897	1156	944	1208	969	1145 (936)
CP+LS	1148	382	1238	411	1293	427	1226 (407)
CP+SF	1115	275	1205	298	1261	312	1194 (295)
CP+M	1189	410	1285	446	1344	468	1273 (441)
Mean	1188	2073/899/661/924	1282	2182/965/717/1002	1339	2238/1003/749/1045	

Effect of foliar spray on quality of chickpea based intercropping

Protein content

It was evident from the data that all the intercropping systems attained a higher value in protein content over sole cropping. Chickpea + mustard (6:2) was found to have maximum protein content (Table 2) among the intercropping systems followed by Chickpea + linseed (6:2), Chickpea + safflower (6:2) and Chickpea + wheat (6:2). The maximum protein content of chickpea when intercropped with mustard and linseed might be due to increased activity of nitrate reductase enzyme. Higher nitrogen in seed is directly responsible for higher protein content because it is a primary component of amino acids which constitute the basis of protein. Similar results were reported by Singh and Rathi, 2003; Kumar and Singh, 2006 and Singh and Aulakh, 2017.

Under the foliar sprays, 1% NPK (19:19:19) showed maximum protein content in chickpea and the intercrops, viz. wheat, linseed, safflower and mustard. Foliar application of GA_3 (100 ppm) recorded lesser protein content than 1% NPK (19:19:19) The control treatment (water spray) was found to have produced no increase in the protein content. Chickpea is a legume crop that can fix atmospheric nitrogen and enrich the soil with nitrogen. However, it also requires adequate amounts of nitrogen for its optimal growth and protein synthesis. Therefore, applying NPK fertilizer to chickpea can increase its protein content by providing sufficient nitrogen supply. Palta *et al*., 2005 confirms the above finding.

Oil content

Intercropping had pronounced impact on the oil content of the crops. Oil content of linseed was higher (37.49 %) in chickpea + linseed (6:2) over sole linseed (Table 2). Similarly, chickpea + mustard (6:2) had more oil content (35.08 %) as compared to that of sole mustard. Further, safflower also produced higher oil content (29.30 %) in chickpea + safflower (6:2) intercropping system over sole safflower. The percentage increase in the oil content due to chickpea intercropping was highest in case of mustard (2.24%) followed by linseed (1.74 %) and safflower (1.63 %). Chaoui *et al.*, 2023 who concluded the variation in oil concentration in seed under different intercropping system which supply more nitrogen led to more meristematic growth. More meristematic growth due to higher supply of nitrogen caused diversion of photosynthates more in production of more structural protein for new tissues rather contributing to oil in seeds.

With regards to foliar spray, oil content was obtained under foliar spray of GA_3 (100 ppm) followed by foliar spray of 1% NPK (19:19:19). The least was obtained under the control (water spray). Improvement in seed oil composition can be credited to the activation of the synthesis of various enzymes which are involved in the fatty acids metabolism (Talaat and Gamal, 2007; Dar *et al.*, 2015), thus increasing seed oil contents. Application of GA_3 prompted a similar pattern of response, with

Table 2. Effect of foliar spray of NPK and GA_3 on protein and oil content of chickpea based intercropping system. (Mean of 2019-20 and 2020-21)

Treatment	Protein content (%) CP/W/LS/SF/M	Oil content (%) CP/W/LS/SF/M
Main plot (Intercropping)		
Sole chickpea	19.58	-
Sole wheat	9.01	-
Sole linseed	13.67	36.85
Sole safflower	13.54	28.83
Sole mustard	19.77	34.31
Chickpea + wheat	19.83 (9.09)	-
Chickpea + linseed	20.06 (13.82)	37.49
Chickpea + safflower	19.91 (13.63)	29.30
Chickpea + mustard	20.14 (20.07)	35.08
Sub-plot (Foliar spray)		
Control (Water spray)	19.62/8.91/13.58/13.46/19.57	36.00/27.94/33.32
1% NPK (19:19:19)	20.21/9.16/13.90/13.65/20.33	37.33/29.23/35.07
GA_3 (100 ppm)	19.88/9.06/13.75/13.64/19.86	38.18/30.02/35.70

the oil content being enhanced noticeably. These results are in agreement with the report of Rajpar *et al.* (2011) which showed that application of GA_3 had noteworthy effect on oil content.

Effect of foliar spray on nutrient uptake by chickpea based intercropping

Total nitrogen uptake

The research statistics indicated that chickpea + mustard (6:2) had the highest mean value (Table 3) of total nitrogen uptake, which remained at par with chickpea + linseed (6:2) and chickpea + wheat (6:3) though, it was superior to rest of the intercropping systems and sole crops. Sole safflower had the lowest mean value of total nitrogen uptake. The treatment chickpea + mustard had the highest mean value of total nitrogen uptake because chickpea is a legume, which can fix atmospheric nitrogen through a symbiotic relationship with rhizobia bacteria in the root nodules. This increases the soil nitrogen availability and the nitrogen uptake efficiency of the crops. Moreover, chickpea and mustard have different root architectures and growth habits, which can enhance the root distribution and the spatial and temporal complementarity of nitrogen uptake. Singh *et al*., 2022 and Chaoui *et al*., 2023 confirms the above finding.

A close look into the foliar spray treatment indicates that GA_3 (100 ppm) had recorded the maximum total nitrogen uptake as compared to 1% NPK (19:19:19). While, minimum values were obtained with water spray. Foliar spray of NPK can improve the efficiency of nutrient uptake by increasing photosynthesis, transpiration and nutrient solubility.

Total phosphorus uptake

The inference derived from the investigation signifies that maximum phosphorus uptake (Table 4) was found in sole wheat, which was at par with sole mustard but superior over rest of the sole crops as well as intercrops. The minimum phosphorus uptake was observed for sole safflower. The higher phosphorus uptake by wheat and mustard compared to other crops may be related to their root morphology and physiology, which allow them to explore a larger volume of soil and access more phosphorus sources. The findings align with the existing theories of Vyas and Rai, 1993 and Alam, 2017.

Regarding the foliar sprays, 1% NPK (19:19:19) achieved maximum total phosphorus uptake over foliar spray of GA_3 (100 ppm). Water spray recorded the minimum total phosphorus uptake. Foliar spray of NPK can improve the efficiency of nutrient uptake by increasing photosynthesis, transpiration and nutrient solubility.

Total potassium uptake

A critical examination of data indicated that the highest total potassium uptake (Table 5) is seen in sole mustard which is at par with chickpea + mustard (6:2) and was superior to other sole crops and intercrops. One possible reason for the higher potassium uptake in the intercropped treatments

Table 3. Effect of foliar spray of NPK and GA_3 on total nitrogen uptake of chickpea based intercropping system. (Mean of 2019-20 and 2020-21)

Treatment	Total nitrogen uptake (kg/ha)			Mean
	Control	1% NPK (19:19:19)	GA_3 (100 ppm)	
Sole chickpea	77.93	85.57	87.52	83.67
Sole wheat	69.28	73.15	75.32	72.58
Sole linseed	53.12	57.60	59.81	56.84
Sole safflower	34.55	38.65	39.03	37.41
Sole mustard	71.23	76.51	80.47	76.07
Chickpea + wheat	78.94	86.52	88.24	84.56
Chickpea + linseed	78.72	86.77	88.76	84.75
Chickpea + safflower	71.71	78.94	81.00	77.22
Chickpea + mustard	86.29	96.13	98.26	93.56
Mean	69.09	75.54	77.60	CV%
	SEm±	CD at 5%		
Main plot	5.33	15.97	21.57	
Sub plot	0.54	1.55		
Interaction	5.49	NS		

with chickpea is that chickpea is a legume crop that can fix atmospheric nitrogen and improve soil fertility. This may enhance the availability and uptake of potassium by the companion crops. These findings are in close conformity with the results of Singh and Verma, 2007.

It is transparent from the data that foliar spray of GA_3 attained maximum value of total potassium uptake than 1% NPK (19:19:19). The least was found with control plot. Foliar spray of GA_3 (100ppm) may stimulate the growth and development of the chickpea roots and nodules by providing additional hormones, nutrients and antioxidants. Foliar spray may also increase the resistance of the chickpea plants to biotic and abiotic stresses, such as pests, diseases, drought and salinity.

CONCLUSION

On the basis of the findings obtained from the two years' experimental study, the following broad conclusion can be drawn.The most suitable intercropping system in terms of maximum productivity, protein content, oil content and total nitrogen uptake was found to be chickpea+ mustard (6:2) as compared to other intercropping systems. Maximum total phosphorus uptake was attained in sole wheat, while maximum total potassium uptake

Table 4. Effect of foliar spray of NPK and GA_3 on total phosphorus uptake of chickpea based intercropping system. (Mean data of 2019-20 and 2020-21)

Treatment	Total phosphorus uptake (kg/ha)			Mean
	Control	1% NPK (19:19:19)	GA_3 (100 ppm)	
Sole chickpea	14.86	16.57	16.88	16.10
Sole wheat	22.26	23.67	23.81	23.25
Sole linseed	13.67	14.92	15.23	14.61
Sole safflower	7.61	8.55	8.57	8.24
Sole mustard	15.80	26.14	17.89	19.94
Chickpea + wheat	17.56	19.34	19.61	18.84
Chickpea + linseed	15.96	17.77	18.10	17.28
Chickpea + safflower	13.92	15.62	15.92	15.15
Chickpea + mustard	17.05	19.75	19.57	18.79
Mean	15.41	18.04	17.29	CV%
	SEm±	CD at 5%		
Main plot	2.00	5.98	35.39	
Sub plot	0.53	1.51		
Interaction	2.38	NS		

Table 5. Effect of foliar spray of NPK and GA_3 on total potassium uptake of chickpea based intercropping system. (Mean of 2019-20 and 2020-21)

Treatment	Total potassium uptake (kg/ha)			Mean
	Control	1% NPK (19:19:19)	GA_3 (100 ppm)	
Sole chickpea	52.33	57.81	58.98	56.38
Sole wheat	54.70	57.48	57.67	56.62
Sole linseed	39.26	42.54	43.57	41.79
Sole safflower	40.95	44.40	45.27	43.53
Sole mustard	62.53	69.41	70.16	67.36
Chickpea + wheat	55.29	60.44	61.34	59.02
Chickpea + linseed	53.58	59.26	60.42	57.78
Chickpea + safflower	52.83	58.37	59.80	56.99
Chickpea + mustard	61.17	68.28	69.81	66.42
Mean	52.51	57.55	58.56	CV%
	SEm±	CD at 5%		
Main plot	3.69	11.06	19.69	
Sub plot	0.46	1.31		
Interaction	3.86	NS		

was achieved by sole mustard. Concerning to the foliar sprays, 1% NPK was found to have recorded maximum protein content whereas, GA_3 (100 ppm) was found to be effective in enhancing the productivity, oil content and nutrient uptake of chickpea and the component crops.

Competing interests

Authors have declared that no competing interests exist.

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