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Foliar Spray of NPK and Gibberellic Acid on Growth and Yield of Chickpea Based Intercropping System

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was carried out during *rabi* seasons of 2019-20 and 2020-21 at Birsa Agricultural University, Ranchi, Jharkhand. 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.,* water(control), foliar spray of 1% NPK (19:19:19) and GA_3 (100 ppm). Results revealed that maximum values of growth parameter (like

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plant height, dry matter accumulation), yield attributes (like number of pods, capsules, capitula, siliqua/plant and spikes/m^2, 100-seed weight in chickpea and 1000-seed weight), grain and straw yield as well as harvest index were recorded under chickpea+ mustard (6:2). With regards to different foliar spray treatments, the maximum values for the above-mentioned parameters were found to be higher under the foliar spray of GA_3 (100 ppm) at 45 days after sowing during both the years of experimentation.

Keywords: Chickpea; foliar spray; intercropping; linseed; safflower; wheat; yield.

1. INTRODUCTION

Chickpea is an important pulse crop in India, known for its adaptability and nutritional value. It is a major source of protein (17 to 22%) and other essential amino acids. Chickpea also contributes to soil health and fertility through atmospheric nitrogen fixation *i.e.,* 140 kg N/ha in a growing season [1]. India ranks first in pulse production (27.81 million 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 hawith the productivity 2600 kg/ha [2]. Chickpea constitutes 38% area and 48% production of pulses in India. In Jharkhand, area, production and productivity of chickpea were 2.65 lakh ha, 3.34 lakh tonnes, and 1257 kg/ha, respectively [3]. The major chickpea growing states in India are Maharashtra, Andhra Pradesh, Bihar, Karnataka, Madhya Pradesh, Rajasthan, Uttar Pradesh, Gujarat, Jharkhand, Chhattisgarh and Telangana. Intercropping is a farming practice where different crop species are grown simultaneously on the same piece of land. It helps to reduce risks from pests, diseases and adverse environmental conditions. Intercropping with legumesand cereals can increase yield, land use efficiency, soil conservation and weed, insect and disease control. Intercropping with specific crop species is more productive, profitable and secured than sole cropping. Intercropping of pulses with wheat, mustard, cotton and sugarcane *etc.* is commonly practiced in some parts of India [4]. 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. Intercropping of pulses with cereals and oilseeds can help mitigate the risk of crop failures and improve monetary returns. 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 or pre-soaking treatments 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. It also helps in the translocation of nutrients to reproductive structures like pods and grains. Foliar application utilizes more than 90 per cent of the fertilizer or plant growth regulator by plant. When similar amount is applied to the soil, it absorbs from 10 to 60 per cent. Overall, the use of plant growth regulators and foliar application of NPK can enhance the productivity of chickpea based intercropping system.

2. MATERIALS AND METHODS

2.1 Experimental Site

A field experiment was carried out during *rabi* season of 2019-20 and 2020-21 at Birsa Agricultural University, Ranchi. The monsoon (June to September) is characterized by cloudy weather, high humidity, frequent rains and weak variable surface winds. Generally, South-West monsoon rains starts in the 3rd week of June and continue till 2nd week of October. The average annual rainfall of this area is about 1398 mm. About 85 to 90 per cent of the total average rainfall (1398 mm) occurs during four monsoon months (June to September) and the rest 10 to 15 per cent is received during winter and summer.

2.2 Soil

The soil of the experimental field was sandy loam in texture. The soil was slightly acidic (5.6 pH) in nature. 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 of experiment.

2.3 Treatments Detail

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 3 replications.

2.4 Cultural Practices

The varieties used in the experiment were Birsa chana 3 for chickpea, K 1317 for wheat, Divya forlinseed, A1 for safflower an NRCBH-101 for mustard. The experimental fields were ploughed twice with harrow followed by planking to get fine tilth. Full dose of nitrogen through Urea and DAP, phosphorus through DAP, potash through MOP and lime were applied at the time of 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 half of nitrogen was applied in two equal splits at 30 DAS and 55 DAS as top dressing. GA_3 @100 ppm dilution with water while concentration of NPK @1% was maintained with water, which was sprayed on the crops at 45 days after sowing.

2.5 Observations

Five tagged plants were used for recording plant height, which was measured in centimetersfrom the base of the plant to collar of the flag leaf and expressed in cm. Ranndomly selected plants from the sampling area were used to record the total dry matter production at harvest of crops. The air-dried sampled plants were dried in oven at 60^0 C till they attained a constant dry weight. Total dry matter production was expressed in g/m^2. The number of pods, capsule, capitula and siliqua from the plants were counted and recorded in plant. The average number was taken as the number of pods per plant. The weight of 100 seeds for chickpea and 1000 seeds for wheat, linseed, safflower and mustard were taken from the grain sample. Air-dried plants from each net plot were threshed, cleaned and weight of grains was recorded in kilo grams. Based on this yield per hectare was calculated. The straw yield of chickpea was recorded after complete sun drying from each net plot area and expressed as kg/ha.

3. RESULTS AND DISCUSSION

3.1 Growth Characters

3.1.1 Plant height

Plant height plays an important role in interpretation of growth and development in intercropping research. The inference derived from the findings suggests that chickpea and the intercrops (wheat, linseed, safflower and mustard) showed higher values for plant height under intercropping at harvest (Table 1) as compared to that of the sole cropping. The plant height of chickpea was found to be superior under chickpea+ mustard (6:2) over the other intercropping systemsand the minimum plant height of chickpea was observed in case of sole chickpea. The reason behind this remarkable variation might be due to the spatial complementarity existing among the intercrops and the interspecific competition among the crops for sunlight and other resources. The findings are in support of the existing evidences provided by Sarkar et al. [5]; Wasu et al. [6]; Gobade et al. [7]; Mohammed et al. [8]; Karale et al. [9].

As far as various foliar spray treatments are taken into consideration, maximum values the plant height were observed with the foliar spray of GA_3(100 ppm) followed by foliar spray of 1% NPK (19:19:19). The least values were obtained under the control (water spray). It may be due to the growth promoting action of GA_3 as it stimulates the cell division in the meristematic tissue and increase vegetative growth of plant. Similar findings due to the foliar spray of growth substances were reported by Jeyakumar et al. [10]; Radhika [11]; Upadhyay [12].

3.1.2 Dry matter accumulation

Dry matter accumulation is an indicator of the biomass production and growth rate of the crops. The data obtained for dry matter accumulation at harvest (Table 1) indicated that the dry matter accumulation showed a comparable increase in intercropping over sole cropping (chickpea, wheat, linseed, safflower and mustard). Higher dry matter accumulation in intercropping system was because of the fact that intercropping enhanced the growth of chickpea by improving the resource use efficiency, reducing the weed competition and providing better pest and disease control. Similar variation in dry matter accumulation among different planting patterns has also been reported by Tahir et al. [13].

Table 1. Effect of foliar spray of 1% NPK and GA_3ongrowth parameters of chickpea based intercropping system. (Mean of 2019-20 & 2020-21)

Treatments	Plant height (cm) at harvest	Dry matter accumulation (g/m^2) at harvest	Number of pods, capsule, capitula, siliqua/plants, spike/m^2	1000-seed weight (100-seed weight of chickpea
	CP/W/LS/SF/M	**CP/W/LS/SF/M**	**CP/W/LS/SF/M**	**CP/W/LS/SF/M**
Intercropping				
Sole CP	61.0	472.2	31.4	24.87
Sole W	99.8	840.0	305.6	43.52
Sole LS	78.1	427.0	49.4	7.38
Sole SF	122.9	417.3	7.2	34.82
Sole M	143.9	618.6	121.6	4.52
CP+W	62.6 (101.4)	480.6 (928.5)	31.8(309.1)	23.56 (44.01)
CP+LS	65.9 (81.1)	509.5 (454.0)	33.6 (51.5)	23.83 (7.75)
CP+SF	64.5 (127.6)	500.5 (438.1)	32.8 (7.5)	25.79 (35.72)
CP+M	67.0 (150.4)	520.9 (707.1)	33.9 (127.8)	27.16 (4.75)
Foliar spray				
Control	60.3/96.1/74.7/117.9/137.4	468.7/848.1/415.8/399.1/621.6	30.8/295.4/48.7/6.9/117.8	24.34/95.41/74.63/115.17/137.81
NPK (19:19:19)	64.9/101.4/80.4/126.6/148.9	499.5/888.3/442.0/430.8/667.1	33.0/310.2/50.7/7.5/126.2	25.35/100.18/80.44/124.18/150.29
GA_3(100 ppm)	67.5/104.2/83.8/131.4/155.2	522.0/916.3/463.7/453.3/699.8	34.4/316.4/52.3/7.7/130.0	25.44/102.18/83.86/129.27/156.68

Table 2. Effect of foliar spray of 1% NPK and GA_3 on grain and straw yield of chickpea based intercropping system. (Mean of 2019-20 & 2020-21)

Treatment	Grain yield (kg/ha)	Straw or stover yield (kg/ha)	Harvest index (%)
	CP/W/LS/SF/M	CP/W/LS/SF/M	CP/W/LS/SF/M
Intercropping			
Sole CP	1511	3012	33.32
Sole W	3393	4512	42.91
Sole LS	1505	2539	37.00
Sole SF	1123	2763	28.43
Sole M	1540	4358	26.09
CP+W	1145 (936)	2286 (1244)	33.29 (42.94)
CP+LS	1226 (407)	2412 (679)	33.64 (37.11)
CP+SF	1194 (295)	2379 (725)	33.33 (28.45)
CP+M	1273 (441)	2445 (1186)	34.14 (26.27)
Foliar spray			
Control	1188/2073/899/661/924	2397/2833/1539/1665/1640	33.10/42.27/36.75/28.08/25.92
NPK(19:19:19)	1282/2182/965/717/1002	2516/2883/1622/1752/2809	33.68/43.08/37.12/27.70/26.19
GA_3(100 ppm)	1339/2238/1003/749/1045	2608/2918/1666/1816/2898	33.85/43.44/37.29/28.70/26.43

**CP-Chickpea, W-Wheat, LS-Linseed, SF-Safflower and M-Mustard. Values in parenthesis are the mean values for the intercropping*

With regards to foliar application, maximum dry matter was accumulated under foliar spray of GA_3(100 ppm) followed by foliar spray of 1% NPK (19:19:19). The minimum dry matter was accumulated under the control (water spray) treatment. This variation occurred because GA_3 increases the dry matter in chickpea 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 dry matter accumulation. Similar findings due to the foliar spray of growth substances were reported by Kachave et al. [14]; Sandbhor, [15].

3.2 Yield Attributes

3.2.1 Number of pods, capsule, capitula, siliqua/plant and spike/m^2, 1000-seed weight

The data related to yield attributes like number of pods, capsule, capitula, siliqua/plant spike/m^2 and test weight of grains were comparatively higher in the intercropping systems than the sole cropping. Chickpea produced maximum number of pods/plant (Table 2) under chickpea+mustard (6:2) intercropping system. This comparable increase with mustard intercropping may be due to the better utilization of growth and development resources provided by the spatial arrangement accompanied by the root nodulation which increased the nitrogen content in the soil. Bishnoi et al. [16] confirms the above result.

With regards to the foliar application of 1% NPK (19:19:19) and GA_3 (100 ppm), the higher values of all the yield attributes were recorded with the foliar spray of GA_3 (100 ppm) compared to that of the foliar application of 1% NPK (19:19:19). The lowest values were observed in case of water spray (control). This visible increase due to the foliar spray of GA_3 (100 ppm) is in accordance with the findings of Chauhan et al. [17].

3.2.2 Grain and straw yield (kg/ha)

Yield is the ultimate product which is more desirable and leaves produce photosynthates which ultimately contribute to yield. Chickpea based intercropping system effectively influenced the grain and straw yield of the crops. The mean grain and straw yield were higher in case of sole cropping (Table 2) over intercropping systems during both years. This increase was due to more plant population available in sole cropping. The lesser number of crop geometry of component crops in the intercropping system resulted in the reduction of grain and straw yield of the intercropping systems. The data exhibited higher values of grain yield and straw yield with the foliar spray of GA_3 (100 ppm) compared to that of the foliar application of 1% NPK (19:19:19). The lowest values were observed in case of water spray (control). The findings were in corroboration with that of Chauhan et al. [17].

3.2.3 Harvest index (%)

The mean data on harvest index as influence by chickpea based intercropping system through foliar spray of 1% NPK (19:19:19) and GA_3 (100 ppm) suggested that the harvest index of chickpea was maximum when intercropped with linseed (Table 2) and minimum with wheat. Similarly, the harvest index of wheat, linseed, safflower and mustard was found to be higher when intercropped with chickpea over sole cropping.

Additionally, GA_3 (100 ppm) was found to be the best among the foliar treatments for obtaining a higher harvest index.

4. CONCLUSION

On the basis of the findings obtained from the two years of this study, the following conclusion can be drawn. The most suitable intercropping system in terms of maximum growth characters, yield and yield attributes was found to be chickpea + mustard (6:2) as compared to other intercropping systems. Regarding the foliar sprays, GA_3 (100 ppm) was found to be effective in enhancing the growth characters, yield and yield attributes of chickpea and the component crops.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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