# アルファルファ除蛋白液の液体肥料としての利用


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# Utilization of Alfalfa (*Mediacago sativa* L.) Whey as a Fertilizer in Irrigation

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**Synopsis**

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Most of the legume crops need adequate fertilization to maintain high herbage yields. 'Whey' a by-product in alfalfa leaf protein production pilot plant was utilized as a fertilizer in irrigation. The effect on seed germination, plant growth and root nodule development in legume crops like cowpea (*Vigna sinensis* L.), green gram (*Phaseolus aureus* Roxb.) and groundnut (*Arachis hypogea* L.) were studied in laboratory and glasshouse conditions. In laboratory, seed germination and root length were decreased as the concentration of whey increased. However, a slight increase in shoot length was observed at 10% concn. (diluted 10 times) of whey. Inhibitory effects at higher concentrations of whey were also confirmed in glasshouse. Cowpea and groundnut were not so affected by being whey supplied at 20%, but green gram was damaged. It is observed that, higher concentrations of whey caused growth retardation, plant damage or death. Probably 10% or below concentration of whey and less number of applications would be useful as a fertilizer in irrigation.

**Key Words** : Green crop fractionation, Alfalfa whey, Use in irrigation, Inhibitory effects.

## Introduction

In green crop fractionation the dry matter (DM) of a crop is distributed among three products (−) leaf protein concentrate (LPC), press cake (PC) and whey. Each will be more valuable when separated from each other than in the original form. The first product - LPC is protein-pigment rich material fit for feed or food use and the second major product - PC is useful for ruminants in fresh or ensiled form.

Of the three products, the third product - whey also called deproteinised juice (DPJ), brown juice (BJ) or liquor contains large amount of soluble carbohydrates, peptides, free amino acids, vitamins and minerals and has been attracted little attention of the researchers so far than either the LPC or PC. Because of its high BOD and consequent high costs of disposal, it is essential that either uses must be found for it or it should be disposed off in some manner

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that will avoid pollution of the environment.

There are many possible ways in which whey can be utilized (−) the most important being (a) as a ruminant feed ; (b) for the production of chemicals ; (c) for the cultivation of microorganisms and (d) as a fertilizer in irrigation.

Addition of whey stimulated the growth of gas-forming bacteria such as *Clostridium butyricum* and *C. pasteurianum*, the carbohydrates in whey can improve the structure of intractable soils ; this effect persists after the gases escape because of soil stabilisation by bacterial polysaccharides (ARKCOLL[1]). Application of whey to crops would reduce storage capacity needs and take advantage of its mineral content. Therefore, the objective of this investigation was to determine whether different concentrations of alfalfa whey effect on seed germination, plant growth and root nodule development of different legume plant species in laboratory and glasshouse conditions.

## Materials and Methods

The 'whey' a by-product was obtained from 'Bidkin process' after leaf protein extraction from alfalfa crop. The chemical composition and fertilizer value of this process were reported previously (REDDY and JOSHI[5,6]). The seeds were collected from local market which included : legume crops - (pulses) - cowpea (*Vigna sinensis* L.) and green gram (*Phaseolus aureus* Roxb.) and anoil seed plant - groundnut (*Arachis hypogea* L.).

Different concentrations of whey (10-100%) were made using distilled water. ISTA technique was adopted to calculate seed germination. The seeds were soaked in their respective concentration treatment of whey for 6 hours before incubation in petridishes. After 5 days per cent seed germination, seedling root and shoot lengths were measured.

In glasshouse experiment, pots were filled with local agricultural field soil (Black soil). Tap water was used for control and also to prepare different concentrations of whey (20, 40, 60, 80 and 100%). Totally, ten applications were made in 34 days of the experiment. Each time, 300 m*l* of above concentration of whey was supplied to the pots of cowpea, green gram and groundnut.

## Results and Discussion

As the concentration of whey increased there was corresponding decline in the percentage of seed germination with figures 100-40, 100-80 and 40-10% in cowpea, green gram and groundnut. A similar effect was found in root and shoot development (Table 1). The shoot length increased little at 10% level dose. However, at concentration higher than that, gradual decline was noticed from 4.6 to 1.0 and 7.0 to 1.0 cm for cowpea and green gram. In case of groundnut the shoot could not develop properly. The root development considerably decrea sed in all three plants at higher concentrations of whey. The decline in root length, on an average, was 4.9-0, 3.6-1.0 and 4.0-0.5 cm for cowpea, green gram and groundnut respecti vely. Athigher concentrations seeds were shrinken in nature, the root could not develop much and root tip portions turned to black colour or became rotten.

An experiment conducted in pots under glasshouse condition shows the percentage seed germination and average plant growth after 34 days of irrigation with different concentrations

Table 1. Average % seed germination and seedling growth on 5th day in blotter paper method with different concentrations of alfalfa whey treatment

| Seed | | Concentration of whey (%) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0 | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 |
| *Pulses* | SG | 100 | 100 | 100 | 100 | 90 | 100 | 80 | 80 | 60 | 40 | 40 |
| Cowpea | SL | 4.45 | 4.60 | 3.70 | 2.60 | 2.66 | 2.55 | 1.75 | 1.40 | 1.00 | 1.00 | 1.00 |
| | RL | 4.90 | 3.70 | 3.10 | 3.10 | 1.66 | 2.33 | 1.25 | 1.50 | 1.00 | 0.00 | 0.00 |
| | SG | 100 | 100 | 100 | 100 | 90 | 100 | 100 | 90 | 100 | 80 | 90 |
| Green gram | SL | 5.30 | 7.00 | 4.75 | 3.00 | 2.75 | 1.88 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| | RL | 3.60 | 3.00 | 2.00 | 2.00 | 1.41 | 1.22 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| *Oil seed* | SG | 40 | 40 | 50 | 40 | 40 | 10 | 30 | 20 | 10 | 10 | 10 |
| Groundnut | SL | — | — | — | — | — | — | — | — | — | — | — |
| | RL | 4.00 | 3.00 | 3.00 | 2.30 | 2.00 | 2.00 | 1.30 | 1.50 | 1.00 | 0.50 | 0.50 |

O=Control, SG=Seed germination (%), SL=Shoot length in cm, RL=Root length in cm, —=No development.

of alfalfa whey supplied (Table 2). Similar to the laboratory experiment, the decline in growth was found at higher concentration of whey application to cowpea, green gram and groundnut. The seed germination was decreased about 50% in pulses. However, in groundnut plant seed germination was not affected except for a 10% increase at 40% dose of whey. The plant growth was gradually decreased 23.5–10.2, 22.8–8.2 and 14.6–3.3 cm for cowpea, green gram and groundnut respectively. Cowpea and groundnut were not so affected by whey application at 20%, but green gram was much damaged.

The main root and lateral root nodule development was also affected as concentration of the whey increased (Table 3). On main root system on an average, the number of nodules were 11–3, 23–1 and 14–1 for cowpea, green gram and groundnut respectively. The only exception in groundnut was at 20% level, where nodules were more in number than that of control. In case of the lateral root system, nodules were similarly reduced – cowpea 2–1, green gram 12–0 and groundnut 15–0.

REAM *et al.*[4] showed that the deproteinised alfalfa juice (DAJ) can be applied safely and will increase herbage production of alfalfa, bromegrass (*Bromus inermis* Leyss.) and corn (*Zea mays* L.). COLLINS[2] report suggests that the 1 cm application rate of whey reduced yield and in some cases killed a portion of the plants. WALGENBACH *et al.*[8] indicate that when higher

Table 2. Average % seed germination and plant growth with different concentrations of alfalfa whey irrigated in pots over one month (34 days)

| Plant | | Concentration of whey (%) | | | | | |
|---|---|---|---|---|---|---|---|
| | | Control | 20 | 40 | 60 | 80 | 100 |
| *Pulses* | SG | 100 | 90 | 90 | 60 | 70 | 50 |
| Cowpea | PG | 23.5 | 23.6 | 12.6 | 9.6 | 7.7 | 10.2 |
| | SG | 100 | 100 | 90 | 100 | 100 | 60 |
| Green gram | PG | 22.8 | 17.7 | 12.7 | 15.7 | 9.2 | 8.2 |
| *Oil seed* | SG | 60 | 60 | 70 | 60 | 60 | 60 |
| Groundnut | PG | 14.6 | 13.5 | 8.7 | 10.5 | 5.6 | 3.3 |

SG=Seed germination (%), PG=Plant growth in cm.

Table 3. Average number of root nodule development with different concentrations of alfalfa whey irrigated in pots over one month (34 days)

| Plant | | Concentration of whey (%) | | | | | |
|---|---|---|---|---|---|---|---|
| | | Control | 20 | 40 | 60 | 80 | 100 |
| *Pulses* | MR | 11 | 10 | 3 | 3 | 3 | 3 |
| Cowpea | LR | 2 | 2 | 2 | 2 | 1 | 1 |
| Green gram | MR | 23 | 12 | 4 | 1 | 1 | 1 |
| | LR | 12 | 8 | 6 | 4 | 2 | 0 |
| *Oil seed* | MR | 14 | 20 | 13 | 8 | 1 | 1 |
| Groundnut | LR | 15 | 14 | 6 | 6 | 1 | 0 |

MR=Main root, LR=Lateral root.

rates of DAJ were applied some damage or death of plants, particularly with alfalfa and corn was occured. WELCH *et al.*[9] observed that, the source of DPJ was not the major factor in alfalfa plant damage, but the rate of application was a major factor. Saponins did not appear to be a damaging agent.

Recently, SALVE and GANGAWANE[7] irrigated soil with undiluted fresh whey from lucerne. It did not affect nodulation in groundnut but slightly increased the growth and DM of plants. A 1 : 1 dilution showed about two-fold increase in nodulation and half-fold increase in DM. Population of Rhizobium, Actinomycetes and other bacteria increased in the rhizosphere and soil. Review data of PIRIE[3] reveal that wheys contain some phytotoxic organic compounds. These phytotoxic products may also be formed in the soil by the action of soil microflora. It is, however, worth recording that the triacontanol in lucerne extracts stimulates the growth of several plants.

In the present study, plants that received the maximum concentration of whey did not develop properly and indicated symptoms of stuntedness, chlorosis, physiological disorders and plant damage or death were observed. As the concentration of whey increase, the stiffness in the upper portion of the soil in glasshouse experiment was observed. The stiffness of the upper layer of soil in pots prevented roots to grow and aeration to the root portions. Undoubtedly, it depends on the composition, concentration, rate of application, quality of supplied to the soil and the type of soil involved. It appears likely that the organic constituents, microbial population and their exudates are probably the main possible causes for the poor seed germination, plant growth, decrease or damage. Although no phytotoxic compounds have been identified either in the present experiment or from results obtained by other workers, the information reported strongly suggests that they occur. Nevertheless, we feel that, whey stimulates plant growth to an extent that cannot easily be explained as the result of the presence of nitrogen, phosphorus and potassium etc. Probably 10% or below concentration of whey and less number of applications would be useful as a fertilizer in irrigation.

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# アルファルファ除蛋白液の液体肥料としての利用

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## 要　約

マメ科作物から茎葉を経済的に高収量で得るためには，適度の施肥が必要である。本試験では，アルファルファの成分分画時に副産物として得られる除蛋白液（Whey）の液体肥料としての利用について実験室及びガラス室規模で検討した。供試植物としてカウピー（*Vigna sinensis* L.），グリーングラム（*Phaseolus aureus* Roxb.）及び落花生（*Arachis hypogea* L.）を用い，それらの発芽，成長及び根粒形成を調査した。

湿潤ろ紙上における発芽試験では，whey の濃度を上げるに従い発芽率及び根長が低下した。葉長は whey 10% 溶液（whey を 10 倍に希釈）の施用区が対照区より長い傾向にあったが，whey 20% 以上の溶液の施用により低下した。

ガラス室内のポット実験では，whey 20% 以上の溶液の施用はすべての植物に抑制効果を示した。whey 20% の溶液の施用で，カウピー及び落花生はあまり影響をうけなかったが，グリーングラムはダメージをうけた。

以上のごとく，高濃度の whey 溶液の施用は植物の成長を阻害し場合によっては死に至らしめるが，低濃度の場合はこのような事が起こらなかったことから，10% あるいはそれ以下に希釈して施用するなら水及び養分の給源として有効と考える。

**キーワード**：アルファルファホエイ，液肥，抑制効果
緑葉成分分画.

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