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Enhancing yield and quality parameters of Clusterbean [*Cyamopsis tetragonoloba* (L.) Taub] through various stress mitigating chemicals and foliar application of liquid manures

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Abstract

A field experiment entitled “Effect of Stress Mitigating Chemicals and Foliar Application of Liquid Manures on Clusterbean [*Cyamopsis tetragonoloba* (L.) Taub]” was conducted on plot number 6A at Agronomy Farm, S.K.N. College of Agriculture, Jobner (Rajasthan) during *khari*f, 2023 on loamy sand soil. The experiment consisting of sixteen treatment combinations with four stress mitigating chemicals (Control, salicylic acid @ 100 ppm, thiourea @ 500 ppm and potassium nitrate @ 2%) and four treatment of liquid manures (Control, panchagavya @ 3%, cow urine @ 10% and vermiwash @ 10%) which were replicated three times in Factorial Randomized Block Design. Results showed that foliar application of thiourea @ 500 significantly increased number of branches per plant, number of pods per plant, seeds per pod, seed yield (13.19 q/ha), haulm yield, biological yield, total uptake of nitrogen, phosphorus and potassium, nitrogen and phosphorus content in seed and protein content in seed of clusterbean over control and salicylic acid @ 100 ppm and remained at par with potassium nitrate @ 2%. However, nitrogen content in haulm and potassium content in seed and haulm found highest with the foliar application of potassium nitrate @ 2%. Among foliar application of liquid manures, panchagavya @ 3% found significantly superior and gave maximum number of branches per plant, number of pods per plant, seeds per pod, seed yield (13.38 q/ha), haulm yield, biological yield, nitrogen and phosphorus content in seed, total uptake of nitrogen, phosphorus and potassium and protein content in seed of clusterbean over control and cow urine @ 10% and remained at par with vermiwash @ 10%. However, maximum nitrogen content in haulm and potassium content in seed were found under the treatment having foliar application of vermiwash @ 10%. Hence, foliar application of thiourea @ 500 ppm and panchagavya @ 3% may be recommended to achieve higher yield and improved quality of clusterbean.

Keywords: Clusterbean, cow urine, liquid manure, panchagavya, potassium nitrate, salicylic acid, stress mitigating chemical, thiourea, vermiwash

Introduction

Clusterbean (*Cyamopsis tetragonoloba* (L.) Taub), commonly known as guar, is an annual, self-pollinated crop belonging to the legume family (Leguminaceae). It is grown during both the *khari*f and summer seasons, particularly in the arid and semi-arid regions of India. It is a rich source of nutrients, containing carbohydrates (38.8–59.0%), crude protein (28.3–35.0%), gum (23.9–35.0%), crude fiber (4.15–8.0%), ash (3.5–6.0%), and fat (1.8–5.2%) (Pathak *et al.*, 2011)^[20]. It is cultivated in several countries, including India, Pakistan, USA, Sudan, South Africa, Brazil, Malawi, Zaire, and Australia. Among these, India is the largest producer, contributing about 80% of the world's total production, followed by Pakistan with 10–15%. In India, clusterbean is mainly grown in the states of Rajasthan, Gujarat, Punjab, Haryana, Uttar Pradesh, and Maharashtra. It is cultivated over an area of about 3.21 million hectares with a total production of 1.78 million tonnes and an average productivity of 556 kg per hectare (Anonymous, 2022–23a)^[3]. Rajasthan alone accounts for nearly 80% of the country's total clusterbean production. The major growing districts in the state include Bikaner, Churu, Jaipur, Jhunjhunu, and Sikar. In Rajasthan, the crop is grown on about 2.29 million hectares, producing

1.16 million tonnes with an average productivity of 540 kg per hectare (Anonymous, 2022–23b) ^[4].

Drought poses a major challenge in water-scarce regions such as Rajasthan. Limited water availability directly restricts plant growth and reduces productivity (Cevik, 2021) ^[8]. Drought conditions are becoming progressively severe prolonged and frequent due to delayed onset and early withdrawal of the monsoon and uneven distribution rainfall in all areas which are leading to diminished plant growth and productivity (Demirhan *et al.*, 2019) ^[12]. Stress mitigating chemicals play an important role in mitigating stress enhancing flower formation, improving crop yield and enhancing the nutrient status of various crops (Singh *et al.*, 2023) ^[24]. Salicylic acid derived from the Latin word "salix" meaning willow trees is extensively utilized in organic synthesis and functions as a stress-mitigating chemical. It also reduce sodium uptake but increasing potassium absorption (Amiri *et al.*, 2021) ^[2]. Thiourea contains both sulphur and nitrogen components with 42.1% sulphur and 36.8% nitrogen thus acting in plant physiology as both a sulphahydril compound and an amino compound similar to urea. It helps in enhancing crop productivity and serves as a resolve against various stresses including drought (Choudhary *et al.*, 2020) ^[11]. Potassium nitrate (KNO₃) is a chemical which can impact on growth, amount of nitrate, its reduction and assimilation in plants. It contains 44-46% K₂O and 13% N. Under stressful conditions, it is capable of reducing the rate of respiration and increasing the absorption of water which leads to an increment in yield. Also, this element increases cell turbulence under stress conditions and reduces the adverse effect of reactive oxygen species (Aslam *et al.*, 2021) ^[5].

Foliar application liquid manures offers the advantage of rapid and efficient nutrient absorption, minimizing losses from leaching and fixation, regulating nutrient uptake by plants and also increasing the soil microbial activity and population which positively influencing crop growth and yield (Manonmani and Srimati, 2009) ^[19]. Panchagavya is an organic preparation derived from cow products including dung, urine, milk, curd and ghee. It serves as an effective organic solution for promoting plant growth and boosting immunity within the plant system. It acts as an effective plant growth substance enhancing crop yield and increasing the biological efficiency of crops (Gore and Sreenivasa, 2011) ^[15]. Consequently, it can serve as a viable alternative to chemical fertilizers in sustaining clusterbean crops. Cow urine retains antifungal properties and serves as a rich source of plant nutrients containing approximately 1.0% nitrogen, traces of phosphorus and 1.0% potassium. It also functions as a natural disinfectant and insect repellent. When cow urine is applied to the soil than it enhances soil texture and moisture retention. Approximately 2400 to 2500 litres of urine are produced annually per animal (Bhawariya *et al.*, 2022) ^[7]. Vermiwash is a liquid organic manures obtained after water passes through a column of worm concentrations (Chattopadhyay, 2014) ^[9]. Treatment with vermiwash raised up the levels of total macronutrients (N, P, K and carbon) as well as micronutrients (Iron, copper and zinc).

Materials and Methods

The experiment was carried out on plot number 6A at Agronomy farm, S.K.N. College of Agriculture, Jobner. Geographically, Jobner is situated 45 km west of Jaipur at 26° 05' North latitude, 75° 28' East longitude and at an altitude of 427 m above mean sea level. The area falls in agro-climatic zone-IIIa (Semi-arid eastern plain zone) of Rajasthan. During the crop season, the maximum temperature ranged from 32.1 °C to 37.0 °C, while the minimum temperature varied between 15.5

°C and 24.0 °C. The soil of the experimental field was loamy sand in texture and alkaline in nature, with a pH of 8.3 and an electrical conductivity (ECe) of 1.42 dS/m. It was low in organic carbon (0.18%) and available nitrogen (126 kg/ha), while it had medium levels of available phosphorus (16.80 kg/ha) and potassium (154.4 kg/ha). The experiment consist of of sixteen treatment combinations, each replicated thrice, with four stress mitigating chemicals (Control, salicylic acid @ 100 ppm, thiourea @ 500 ppm and potassium nitrate @ 2%) and four treatment of liquid manures (Control, panchagavya @ 3%, cow urine @ 10% and vermiwash @ 10%) in Factorial Randomized Block Design (FRBD).

The recommended dose of fertilizer i.e. 40 kg N/ha and 20 kg P₂O₅/ha for clusterbean was applied equally as basal after field preparation. Seeds of the clusterbean variety, 'RGC-1033' were sown on 11th July, 2023 using a seed rate of 20 kg/ha. Two foliar spray of Salicylic acid, Thiourea and KNO₃ @ 100 ppm, 500 ppm and 2%, respectively were done at vegetative and pre flowering stage. Also two foliar spray panchagavya @ 3%, cow urine @ 10% and vermiwash @ 10% were done at vegetative and pre flowering stages. In order to evaluate the effect of different treatments on yield and quality parameters of clusterbean were recorded using standard procedures. The number of branches of five tagged plants from each plot were counted at the time of harvest. Mean number of branches per plant in each plot was worked out and recorded. Total number of pods of the five plants already selected were counted and mean value for number of pods per plant was calculated. Ten pods were selected from each plot from previously selected plants and number of seeds per pod were counted and mean value for number of seeds per pod was calculated. One thousand seeds were counted from each sample drawn from the produce of each plot and their weight was recorded. After thorough sun drying of harvested material, weight was taken for biological yield kg per plot and then converted to q/ha. After threshing, winnowing and cleaning, the produce of each plot was weighed separately in kg per plot and then converted to seed yield in q/ha. Haulm yield (q/ha) was obtained by subtracting the seed yield (q/ha) from biological yield (q/ha).

Harvest Index is also known as efficiency index and it is calculated by the following formula given by Rosielle and Frey (1975) ^[22] which is expressed as:

$$\text{Harvest index (\%)} = \frac{\text{Economical yield (q/ha)}}{\text{Biological yield (q/ha)}} \times 100$$

The representative samples of seed and haulm drawn at the time of threshing that were first oven dried and then grind by electrical grinder stainless steel willey mill were analyzed for their nitrogen, phosphorus and potassium content. Nitrogen was estimated by digesting the samples with sulphuric acid using hydrogen peroxide to remove black color. Estimation of nitrogen was done by colorimetric method using Nessler's reagent to develop color (Snell and Snell, 1949) ^[25]. Nitrogen content was calculated and expressed in percentage. The seed and haulm samples were analyzed for phosphorus content by Vanadomolybdo phosphoric yellow color method. Digestion of samples was done by tri-acid mixture and the intensity of color was measured by Spectrophotometer (Jackson, 1973) ^[17]. Potassium content in the samples used earlier was determined by digesting them in tri-acid mixture of HNO₃:H₂SO₄:HClO₄ and was estimated by "flame photometric method" (Bhargava and Raghupathi, 1993) ^[6].

The uptake of nitrogen, phosphorus and potassium by crop was calculated using following formula-

$$\text{Total nutrient uptake (kg/ha)} = \frac{[\text{Nutrient content in seed (\%)} \times \text{Seed yield (kg/ha)}] + [\text{Nutrient content in haulm (\%)} \times \text{Haulm yield (kg/ha)}]}{100}$$

Protein content in seed was calculated by multiplying nitrogen content in seed (%) with a factor 6.25 (A.O.A.C., 1960).

Results and Discussion

Yield attributes and yield

Effect of stress mitigating chemicals

Data (Table 2) obtained from the experiment revealed that test weight of clusterbean did not differ significantly by two foliar application of different stress mitigating chemicals. But an increasing trend was observed due to application of various stress mitigating chemicals as compared to control. foliar application of thiourea @ 500 significantly improved number of branches per plant, number of pods per plant, seeds per pod, seed yield (13.19 q/ha), haulm yield, biological yield of clusterbean over control and salicylic acid @ 100 ppm and remained at par with potassium nitrate @ 2%. The enhanced yield attributes and increased yield achieved through foliar spraying of thiourea, salicylic acid and potassium nitrate are likely attributed to the promotion of crop photosynthesis. This promotion is facilitated by improved photosynthetic efficiency and the optimization of the source to sink relationship. These stress mitigating chemicals play crucial roles in regulating various physiological processes in plants including stomatal closure, ion uptake, inhibition of ethylene biosynthesis, transpiration and stress tolerance. Foliar application of thiourea, salicylic acid and potassium nitrate can lead to enhanced tissue differentiation, particularly from somatic to reproductive tissues. This process increased meristematic activity and the development of floral primordia, ultimately resulting in increased production of pods per plant and a higher number of seeds per pod. Significant enhancement in seed yield due to foliar application of 500 ppm thiourea was also reported Dhaka *et al.* (2022) ^[13] and Singh *et al.* (2023) ^[24].

Effect of liquid manures

The results in table 2 indicated that various type of liquid manures did not recorded any significant variation among the test weight of clusterbean seed. But an increasing trend was recorded due to application of different liquid manures as compared to control. Panchagavya @ 3% found significantly superior and gave maximum number of branches per plant, number of pods per plant, seeds per pod, seed yield (13.38 q/ha), haulm yield, biological yield of clusterbean over control and cow urine @ 10% and remained at par with vermiwash @ 10%. the efficient transfer of both macro and micro nutrients along with their translocation into various parts of the plant likely facilitated the effective utilization of nutrients and growth stimulants through foliar application of liquid manures. This process may have contributed to the improvement of yield attributes in the clusterbean crop. The significant increase in yield could be attributed to the continuous availability of

nutrients throughout different growth stages of clusterbean as well as the enhanced synthesis of carbohydrates and efficient translocation of photosynthates to the developing sink tissues. Similar findings have been also observed by Prajapati *et al.* (2022) ^[21], Purohit *et al.* (2023) and Watsh *et al.* (2023) ^[27].

Quality parameters

Effect of stress mitigating chemicals

Results indicated that foliar application of thiourea @ 500 significantly increased total uptake of nitrogen, phosphorus and potassium, nitrogen and phosphorus content in seed and protein content in seed of clusterbean over control and salicylic acid @ 100 ppm and remained at par with potassium nitrate @ 2%. However, nitrogen content in haulm and potassium content in seed and haulm found highest with the foliar application of potassium nitrate @ 2%. The beneficial impacts of stress mitigating chemicals including enhanced nutrient accumulation in vegetative plant parts and improved metabolism resulted in greater nutrient translocation to the reproductive organs of the crop consequently increasing the contents in both seed and haulm. The increased uptake of N, P and K likely increased from the enhanced content and yield of clusterbean facilitated by foliar spray application of stress mitigating chemicals. This increase in protein content might be result of increased content of nitrogen in seed of clusterbean by foliar application of stress mitigating chemicals which promote protein synthesis. Similar findings have been reported by Gurjar *et al.* (2022) ^[16], Singh *et al.* (2022) ^[23] and Choudhary (2022) ^[11].

Effect of liquid manures

Results also revealed that foliar application of liquid manures, panchagavya @ 3% found significantly superior and gave maximum nitrogen and phosphorus content in seed, total uptake of nitrogen, phosphorus and potassium and protein content in seed of clusterbean over control and cow urine @ 10% and remained at par with vermiwash @ 10%. However, maximum nitrogen content in haulm and potassium content in seed were found under the treatment having foliar application of vermiwash @ 10%. The higher uptake of N, P and K by clusterbean seeds and haulm under foliar application of panchagavya may be attributed to the availability of a greater abundance of macro and micronutrients as well as growth regulators like auxins and gibberellin which supported in producing higher biomass and facilitated better recovery of N, P and K in the plant. Similar effects have been observed by Machhar *et al.* (2021) ^[18]. The significant and positive correlation between the total uptake of N, P and K and seed yield. The utilization of different liquid manures such as panchagavya, vermiwash and cow urine facilitated balanced nutrition for the crop and contributed to the enhancement of quality parameters by offering readily available nutrients, growth hormones and beneficial microbes. Similar, research findings have been observed by Chavda *et al.* (2020) ^[10] and Ghoya *et al.* (2023) ^[14] in clusterbean.

Table 1: Chemical analysis of panchagavya, cow urine and vermiwash

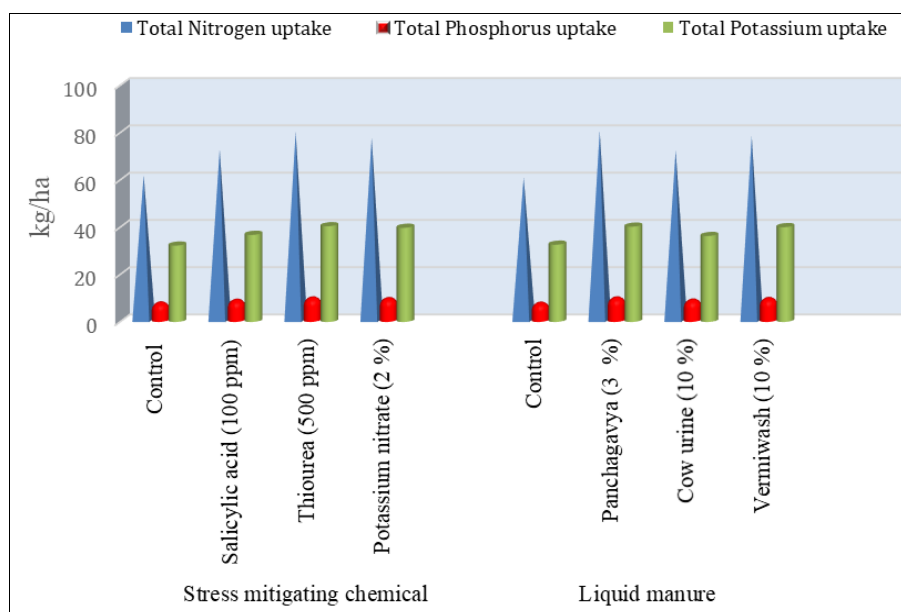
S. No.	Components	Panchagavya	Cow urine	Vermiwash	Methods and references
1	Ph	6.8	7.42	7.6	pH meter method (Jackson,1973) ^[17]
2	EC (dS/m)	10.5	1.36	21.30	Conductivity meter method (Jackson, 1973) ^[17]
3	Organic carbon (%)	0.43	0.008	2.5	Walkley and black wet digestion method (Walkley and Black, 1934) ^[26]
4	Nitrogen	236 ppm	0.45%	0.51%	Microkjeldhal method (Jackson,1973) ^[17]
5	Phosphorus	212 ppm	1.31%	0.02%	Nitric-perchloric (9:4) digestion and colorimetry using Vandomolybdo phosphoric yellow color method (Jackson, 1973) ^[17]
6	Potassium	224 ppm	0.25%	0.61%	Nitric-perchloric (9:4) digestion and flame photometer (Jackson, 1973) ^[17]

Table 2: Effect of stress mitigating chemicals and foliar application of liquid manures on yield attributes of clusterbean

Treatments	Number of branches/plant	Number of pods/plant	Number of seeds/pod	Test Weight (g)
Stress mitigating chemical				
Control	6.5	26.09	7.47	26.26
Salicylic acid (100 ppm)	8.1	29.17	7.99	27.17
Thiourea (500 ppm)	8.5	31.90	8.19	27.73
Potassium nitrate (2%)	8.3	31.25	8.14	27.28
SEm _±	0.20	0.76	0.18	0.59
CD (P = 0.05)	0.58	2.20	0.52	NS
Liquid manure				
Control	6.6	25.89	7.39	26.13
Panchagavya (3%)	8.5	31.54	8.28	27.82
Cow urine (10%)	8.2	29.56	8.03	27.18
Vermiwash (10%)	8.1	31.41	8.09	27.31
SEm _±	0.20	0.76	0.18	0.59
CD (P = 0.05)	0.58	2.20	0.52	NS
CV (%)	8.85	8.91	7.86	7.59

Table 3: Effect of stress mitigating chemicals and foliar application of liquid manures on seed, haulm and biological yields and harvest index of clusterbean

Treatments	Seed yield (q/ha)	Haulm yield (q/ha)	Biological yield (q/ha)	Harvest index (%)
Stress mitigating chemical				
Control	10.89	25.43	36.32	29.95
Salicylic acid (100 ppm)	12.08	27.56	39.64	30.45
Thiourea (500 ppm)	13.19	29.64	42.83	30.77
Potassium nitrate (2%)	12.69	29.01	41.70	30.40
SEm _±	0.38	0.71	1.06	0.66
CD (P = 0.05)	1.08	2.06	3.07	NS
Liquid manure				
Control	10.66	25.28	35.94	29.64
Panchagavya (3%)	13.38	29.58	42.96	31.13
Cow urine (10%)	12.07	27.35	39.42	30.60
Vermiwash (10%)	12.74	29.43	42.17	30.19
SEm _±	0.38	0.71	1.06	0.66
CD (P = 0.05)	1.08	2.06	3.07	NS
CV (%)	10.65	8.85	9.17	7.49

**Fig 1:** Effect of stress mitigating chemicals and foliar application of liquid manures on total nitrogen, phosphorus and potassium uptake of clusterbean

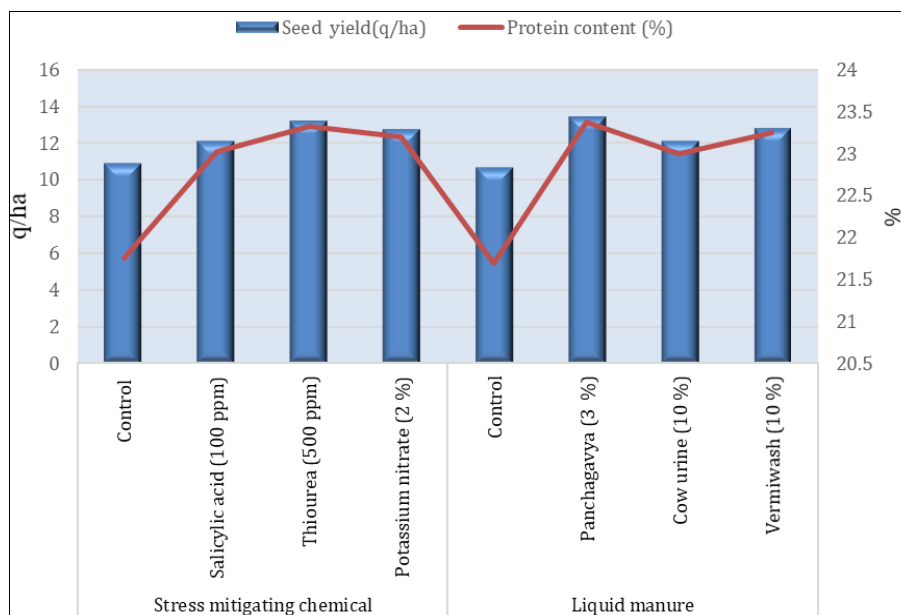


Fig 2: Effect of stress mitigating chemicals and foliar application of liquid manures on seed yield and protein content in seed of clusterbean

Table 4: Effect of stress mitigating chemicals and foliar application of liquid manures on quality parameters of clusterbean

Treatments	Nitrogen content (%)		Total Nitrogen uptake (kg/ha)	Phosphorus content (%)		Total Phosphorus uptake (kg/ha)	Potassium content (%)		Total Potassium uptake (kg/ha)	Protein content (%)
	Seed	Haulm		Seed	Haulm		Seed	Haulm		
Stress mitigating chemical										
Control	3.48	0.91	61.21	0.309	0.174	7.83	0.536	1.04	32.30	21.76
Salicylic acid (100 ppm)	3.68	1.00	72.22	0.334	0.179	8.96	0.562	1.09	36.84	23.02
Thiourea (500 ppm)	3.73	1.02	79.65	0.339	0.183	9.92	0.575	1.11	40.50	23.33
Potassium nitrate (2%)	3.71	1.03	77.18	0.337	0.184	9.64	0.578	1.12	39.84	23.20
SEm±	0.06	0.02	1.88	0.005	0.003	0.24	0.01	0.02	0.89	0.37
CD (P = 0.05)	0.17	0.05	5.43	0.015	NS	0.69	0.03	0.05	2.58	1.08
Liquid manure										
Control	3.47	0.92	60.38	0.311	0.173	7.73	0.524	1.07	32.69	21.69
Panchagavya (3%)	3.74	1.01	80.09	0.339	0.182	9.94	0.577	1.10	40.32	23.38
Cow urine (10%)	3.68	1.00	71.92	0.334	0.182	9.00	0.561	1.08	36.37	23.00
Vermiwash (10%)	3.72	1.03	77.87	0.336	0.183	9.68	0.578	1.11	40.10	23.25
SEm±	0.06	0.02	1.88	0.005	0.003	0.24	0.01	0.02	0.89	0.37
CD (P = 0.05)	0.17	0.05	5.43	0.015	NS	0.69	0.03	NS	2.58	1.08
CV (%)	5.64	5.98	8.98	5.55	5.99	9.15	5.94	5.83	8.27	5.68

Conclusion

The present study revealed that foliar application of stress mitigating chemicals and liquid manures brought significant improvement in yield and quality parameters of clusterbean. Hence, foliar application of thiourea @ 500 ppm and foliar sprays of panchagavya @ 3% showed superiority in terms of the above parameters over other treatments.

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